Star CNN tests

May 8, 2019

0.1 1) Finding the Coupling Coefficients:

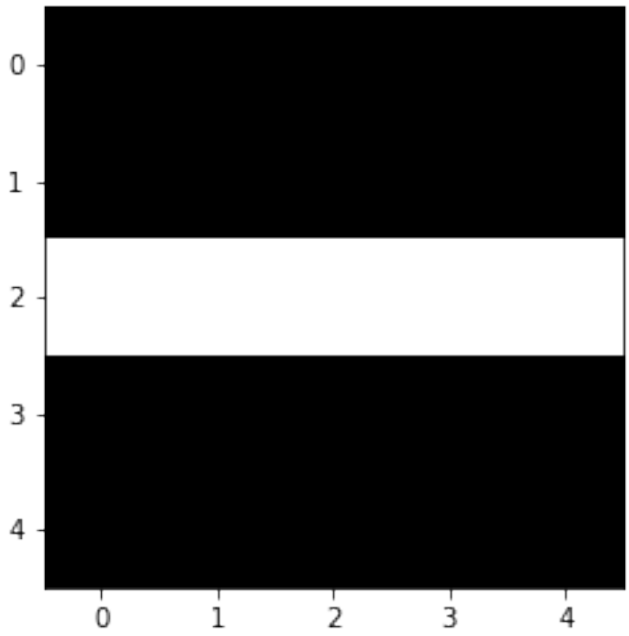
In [2]:
```
import numpy as np
import pickle, gzip, numpy as np
import matplotlib.pyplot as plt
import matplotlib.cm as cm
import math
import random
```

In [3]:
```
sigma_1 = np.array([-1, -1, -1, -1, -1, -1, -1, -1, -1, -1, 1, 1, 1, 1, 1, -1, -1, -1, -
sigma_2 = np.array([-1, -1, 1, -1, -1, -1, -1, 1, -1, -1, -1, -1, 1, -1, -1, -1, -1, 1,
sigma_3 = np.array([1, 1, 1, 1, 1, 1, -1, -1, -1, 1, 1, -1, -1, -1, 1, 1, -1, -1, -1, 1,
sigma_4 = np.array([1, -1, -1, -1, 1, -1, 1, -1, 1, -1, -1, -1, 1, -1, -1, -1, 1, -1, 1,
```

0.1.1 Print the figures:

In [10]:
```
sigma_1_show = np.array(sigma_1).reshape(5, 5)
sigma_2_show = np.array(sigma_2).reshape(5, 5)
sigma_3_show = np.array(sigma_3).reshape(5, 5)
sigma_4_show = np.array(sigma_4).reshape(5, 5)
plt.imshow(sigma_1_show, cmap = cm.Greys_r)
# plt.imshow(sigma_2_show, cmap = cm.Greys_r)
# plt.imshow(sigma_3_show, cmap = cm.Greys_r)
# plt.imshow(sigma_4_show, cmap = cm.Greys_r)
```

Out[10]:
```
<matplotlib.image.AxesImage at 0x7f3ca52a9fd0>
```




```
In [13]: s = np.zeros(shape=(25,25))

         for i in range(25):
             for j in range(25):
                 s[i][j] = 1/25 * (sigma_1[i] * sigma_1[j] + sigma_2[i] * sigma_2[j] + sigma_3[i

         # print(25 * s)
```

This generates a 25 by 25 matrix of the coupling coefficients.

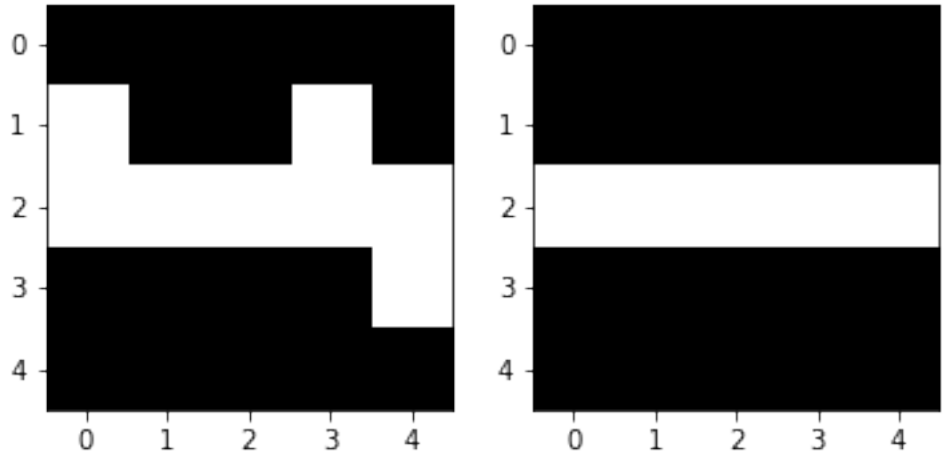
0.2 2) Assign the initial state $v_i(0)$ and update the network:

0.2.1 Test with a sample squares, see if converge.

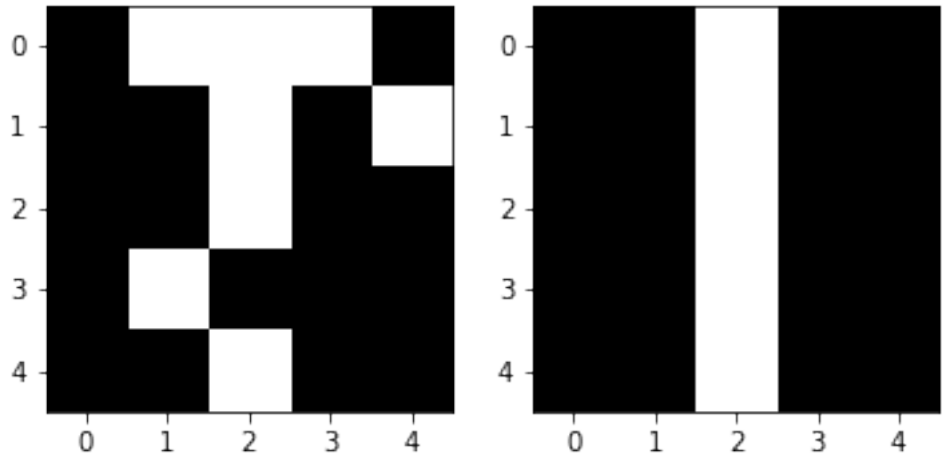
```
In [21]: def tryTest(sigma_test):
             sigma_test_resized = np.array(sigma_test).reshape(5, 5)

             V = sigma_test # this is the initial state (I guess it's the where the tested image
             new_V = np.ones(25)

             for i in range(25):
                 total = 0
                 for j in range(25):
                     total += s[i][j] * V[j]

                 # total signed total is just y
```

```
            if total >= 0:
                new_V[i] = 1
            else:
                new_V[i] = -1

        V = new_V
        # print(V)
        output = np.array(V).reshape(5, 5)

        f = plt.figure()
        f.add_subplot(121)
        plt.imshow(sigma_test_resized, cmap = cm.Greys_r)
        f.add_subplot(122)
        plt.imshow(output, cmap = cm.Greys_r)
        plt.show()
```

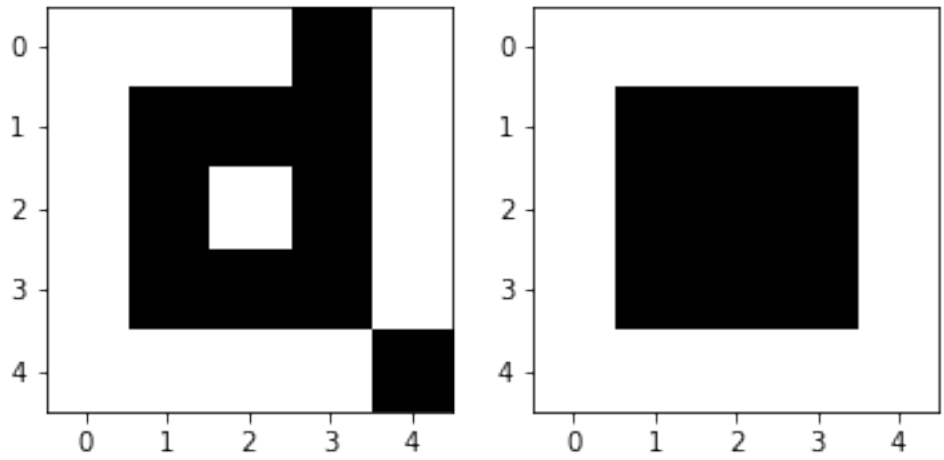
In [25]:
```
sigma_test = np.array([-1, -1, -1, -1, -1, 1, -1, -1, 1, -1, 1, 1, 1, 1, 1, -1, -1, -1,
tryTest(sigma_test)
```



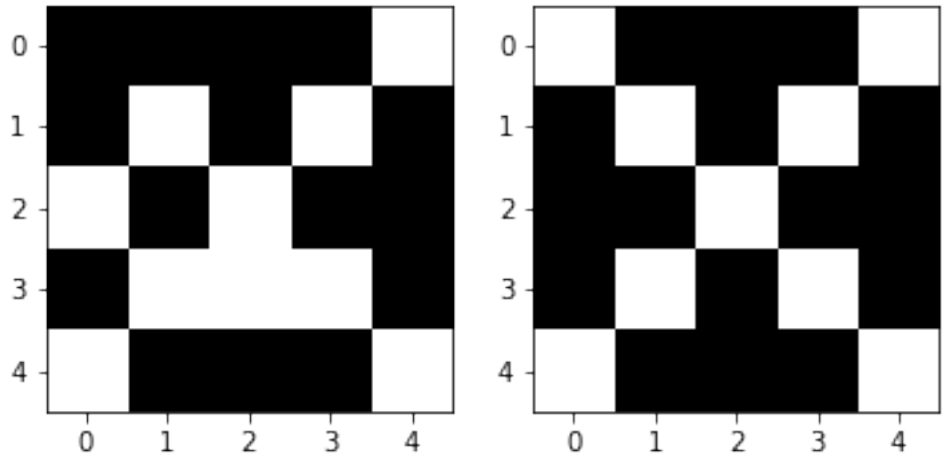
In [24]:
```
sigma_test2 = np.array([-1, 1, 1, 1, -1, -1, -1, 1, -1, 1, -1, -1, 1, -1, -1, -1, 1, -1
tryTest(sigma_test2)
```



In [27]:
```
sigma_test3 = np.array([1, 1, 1, -1, 1, 1, -1, -1, -1, 1, 1, -1, 1, -1, 1, 1, -1, -1, -
tryTest(sigma_test3)
```

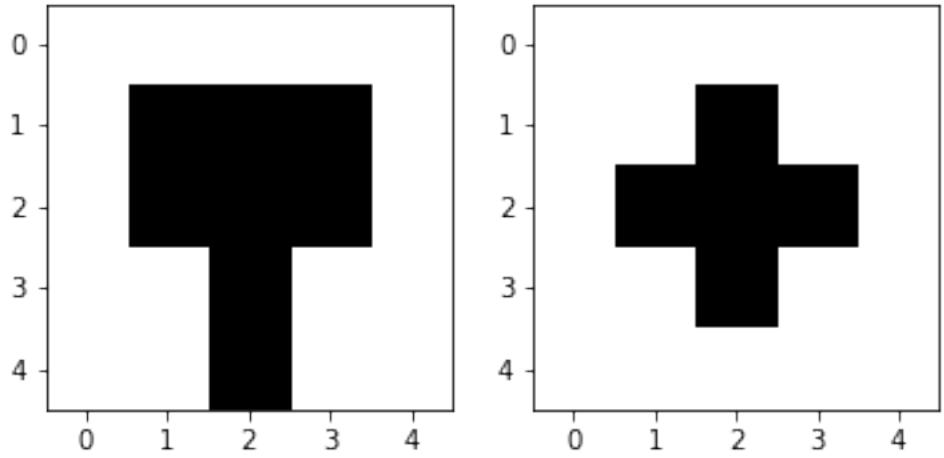


In [28]:
```
sigma_test4 = np.array([-1, -1, -1, -1, 1, -1, 1, -1, 1, -1, 1, -1, 1, -1, -1, -1, 1, 1
tryTest(sigma_test4)
```



The following is a spurious state:

```
In [68]: sigma_test5 = np.array([1, 1, 1, 1, 1, 1, -1, -1, -1, 1, 1, -1, -1, -1, 1, 1, 1, -1, 1,
         tryTest(sigma_test5)
```



First-order Star CNNs (this is the same thing as the basic weight change rules above)

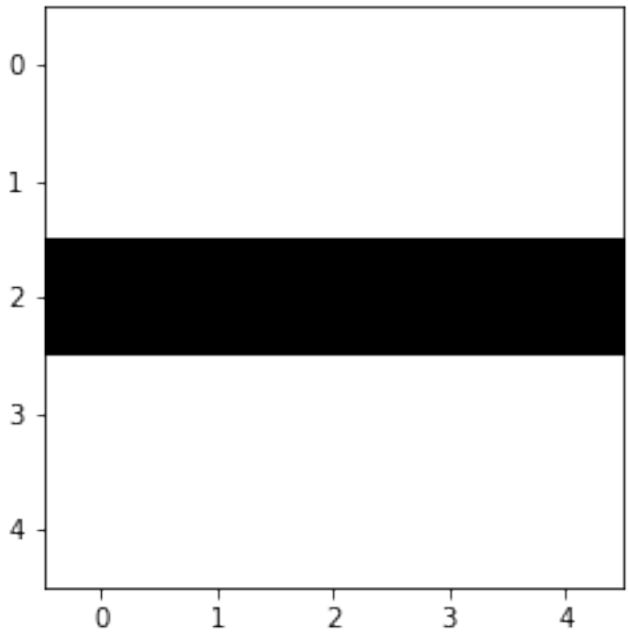
0.3 Second-order Star CNN

0.3.1 1) Two-cell CNNs [Zhou & Nosseck, 1991]

```
In [70]: # this converges on the first pattern
         V = sigma_test
         Y = np.ones(25)
```

```
new_V = np.ones(25)
new_Y = np.ones(25)

def h(x):
    return(1/2 * ((abs(x + 1)) - abs(x - 1)) )

def sgn(x):
    if x >= 0:
        return 1
    else:
        return -1

saved_x = []
saved_y = []
timestamp = 10
for t in range(timestamp):
#     print(V[0])
    saved_x.append(V[0])
    saved_y.append(Y[0])

    for i in range(25):
        p=1.1; q=1.1; r=-2; k=2

        dx = -V[i] + p*h(V[i]) + r*h(Y[i])
        dy = -Y[i] + k*h(V[i]) + q*h(Y[i])

        total = 0
        for j in range(25):
            total += s[i][j] * V[j]

        dx += sgn(total)

        new_V[i] = V[i] + dx
        new_Y[i] = Y[i] + dy

    V = new_V
    Y = new_Y
# print(V)
new_array=[sgn(i) for i in V]
new_array_resized = np.array(new_array).reshape(5, 5)
plt.imshow(new_array_resized, cmap = cm.Greys_r)
```

Out[70]: <matplotlib.image.AxesImage at 0x7f3ca3fd4940>




```
In [ ]: plt.plot([i + 1 for i in range(timestamp)], saved_x)
        plt.xlabel("t")
        plt.ylabel("x")
        plt.show()

        plt.plot([i + 1 for i in range(timestamp)], saved_y)
        plt.xlabel("t")
        plt.ylabel("y")
        plt.show()
```