OT

May 16, 2019

```
In [1]: %matplotlib inline
```

```
In [2]: # Import packages
        !pip install POT
```

```
Requirement already satisfied: POT in /Users/irenevolpe/anaconda3/lib/python3.6/site-packages (0
Requirement already satisfied: numpy in /Users/irenevolpe/anaconda3/lib/python3.6/site-packages
Requirement already satisfied: scipy in /Users/irenevolpe/anaconda3/lib/python3.6/site-packages
Requirement already satisfied: cython in /Users/irenevolpe/anaconda3/lib/python3.6/site-packages
Requirement already satisfied: matplotlib in /Users/irenevolpe/anaconda3/lib/python3.6/site-pack
Requirement already satisfied: cycler>=0.10 in /Users/irenevolpe/anaconda3/lib/python3.6/site-pa
Requirement already satisfied: kiwisolver>=1.0.1 in /Users/irenevolpe/anaconda3/lib/python3.6/si
Requirement already satisfied: pyparsing!=2.0.4,!=2.1.2,!=2.1.6,>=2.0.1 in /Users/irenevolpe/ana
Requirement already satisfied: python-dateutil>=2.1 in /Users/irenevolpe/anaconda3/lib/python3.6
Requirement already satisfied: six in /Users/irenevolpe/anaconda3/lib/python3.6/site-packages (f
Requirement already satisfied: setuptools in /Users/irenevolpe/anaconda3/lib/python3.6/site-pack
```

1 OT for image color adaptation

This example presents a way of transferring colors between two image with Optimal Transport as introduced in [6]

[6] Ferradans, S., Papadakis, N., Peyre, G., & Aujol, J. F. (2014). Regularized discrete optimal transport. SIAM Journal on Imaging Sciences, 7(3), 1853-1882.

```
In [3]: # Authors: Remi Flamary <remi.flamary@unice.fr>
        #          Stanislas Chambon <stan.chambon@gmail.com>
        #
        # License: MIT License

        import numpy as np
        from scipy import ndimage
        import matplotlib.pylab as pl
        import ot


        r = np.random.RandomState(42)
```

```
def im2mat(I):
    """Converts and image to matrix (one pixel per line)"""
    return I.reshape((I.shape[0] * I.shape[1], I.shape[2]))


def mat2im(X, shape):
    """Converts back a matrix to an image"""
    return X.reshape(shape)


def minmax(I):
    return np.clip(I, 0, 1)
```

1.1 Generate data

Exercise Upload you own images using the Files tab to the left and replace values of the **image1** and **image2** variables with your own file names. Make sure that both images have the same dimensions. Afterwards transfer the colors between the two image using the provided code. Observe the results and comment on what you have understood from this optimal transport example.

In [4]:
```
image1 = 'a.jpg'
image2 = 'b.jpg'

# Loading images
I1 = pl.imread(image1).astype(np.float64) / 256
I2 = pl.imread(image2).astype(np.float64) / 256

X1 = im2mat(I1)
X2 = im2mat(I2)

# training samples
nb = 1000
idx1 = r.randint(X1.shape[0], size=(nb,))
idx2 = r.randint(X2.shape[0], size=(nb,))

Xs = X1[idx1, :]
Xt = X2[idx2, :]
```

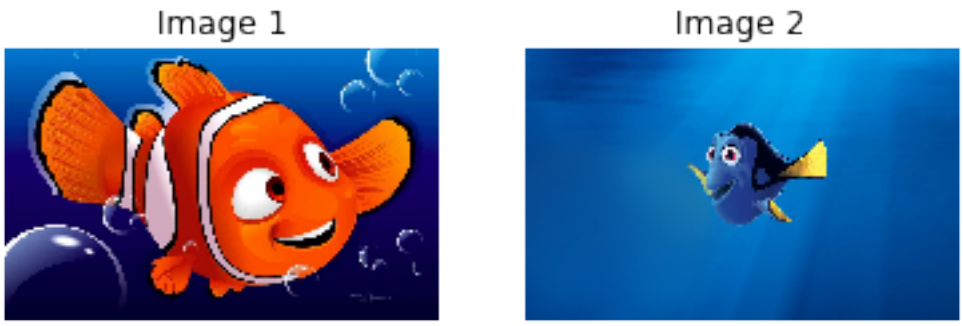
1.2 Plot original image

In [5]:
```
pl.figure(1, figsize=(6.4, 3))

pl.subplot(1, 2, 1)
pl.imshow(I1)
pl.axis('off')
pl.title('Image 1')
```

```
pl.subplot(1, 2, 2)
pl.imshow(I2)
pl.axis('off')
pl.title('Image 2')
```

```
Out[5]: Text(0.5, 1.0, 'Image 2')
```

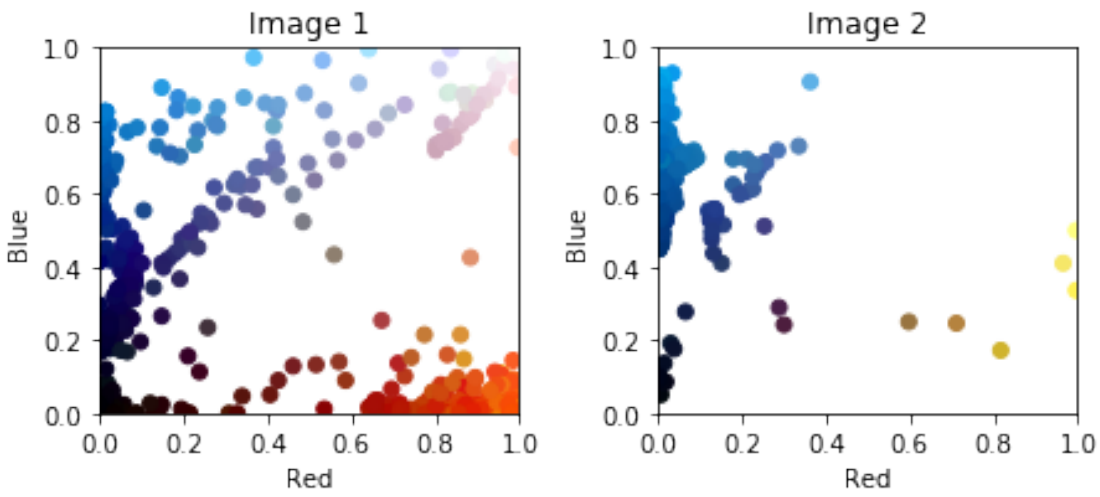


1.3 Scatter plot of colors

```
In [6]: pl.figure(2, figsize=(6.4, 3))

        pl.subplot(1, 2, 1)
        pl.scatter(Xs[:, 0], Xs[:, 2], c=Xs)
        pl.axis([0, 1, 0, 1])
        pl.xlabel('Red')
        pl.ylabel('Blue')
        pl.title('Image 1')

        pl.subplot(1, 2, 2)
        pl.scatter(Xt[:, 0], Xt[:, 2], c=Xt)
        pl.axis([0, 1, 0, 1])
        pl.xlabel('Red')
        pl.ylabel('Blue')
        pl.title('Image 2')
        pl.tight_layout()
```



1.4 Instantiate the different transport algorithms and fit them

In [7]:
```
# Parameters
reg_e = 1e-1 # Entropic regularization term

# EMD (Earth Mover's Distance) Transport
ot_emd = ot.da.EMDTransport()
ot_emd.fit(Xs=Xs, Xt=Xt)

# SinkhornTransport
ot_sinkhorn = ot.da.SinkhornTransport(reg_e)
ot_sinkhorn.fit(Xs=Xs, Xt=Xt)

# prediction between images (using out of sample prediction as in [6])
transp_Xs_emd = ot_emd.transform(Xs=X1)
transp_Xt_emd = ot_emd.inverse_transform(Xt=X2)

transp_Xs_sinkhorn = ot_emd.transform(Xs=X1)
transp_Xt_sinkhorn = ot_emd.inverse_transform(Xt=X2)

I1t = minmax(mat2im(transp_Xs_emd, I1.shape))
I2t = minmax(mat2im(transp_Xt_emd, I2.shape))

I1te = minmax(mat2im(transp_Xs_sinkhorn, I1.shape))
I2te = minmax(mat2im(transp_Xt_sinkhorn, I2.shape))
```

1.5 Plot new images

In [8]:
```
pl.figure(3, figsize=(8, 4))
```

```
pl.subplot(2, 3, 1)
pl.imshow(I1)
pl.axis('off')
pl.title('Image 1')

pl.subplot(2, 3, 2)
pl.imshow(I1t)
pl.axis('off')
pl.title('Image 1 Adapt')

pl.subplot(2, 3, 3)
pl.imshow(I1te)
pl.axis('off')
pl.title('Image 1 Adapt (reg)')

pl.subplot(2, 3, 4)
pl.imshow(I2)
pl.axis('off')
pl.title('Image 2')

pl.subplot(2, 3, 5)
pl.imshow(I2t)
pl.axis('off')
pl.title('Image 2 Adapt')

pl.subplot(2, 3, 6)
pl.imshow(I2te)
pl.axis('off')
pl.title('Image 2 Adapt (reg)')
pl.tight_layout()

pl.show()
```

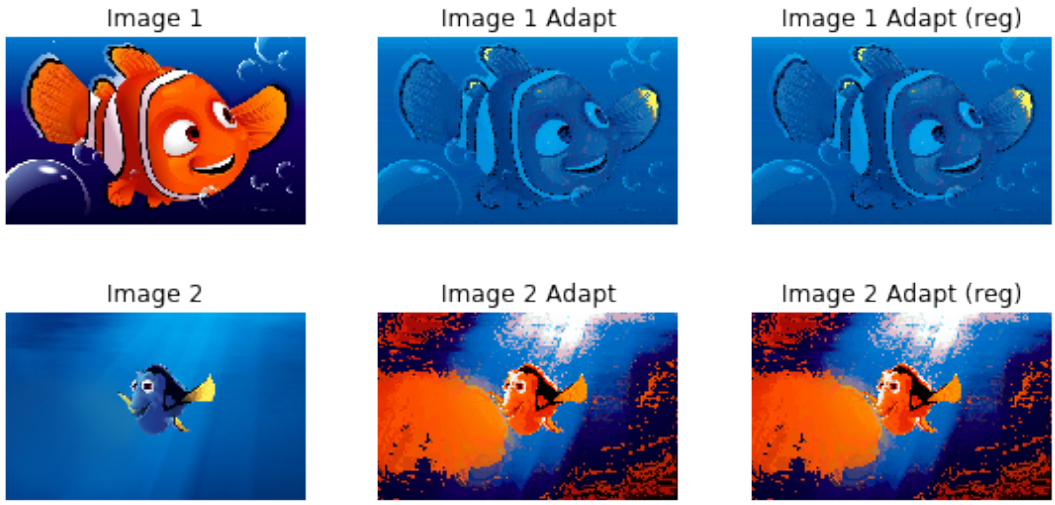


Image 1
Image 1 Adapt
Image 1 Adapt (reg)
Image 2
Image 2 Adapt
Image 2 Adapt (reg)

In [0]: