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# Classification in GPflow

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This script replicates

Hensman, Matthews, Ghahramani, AISTATS 2015, Scalable Variational Gaussian Process Classification, Figure 1 Row 1.

It serves to demonstrate sparse variational GP classification on a simple, easily visualized dataset.

In [1]:

```
from matplotlib import pyplot as plt
plt.style.use('ggplot')
%matplotlib inline
import sys
import csv
import numpy as np
import GPflow
```

In [2]:

```
Xtrain = np.loadtxt('data/banana_X_train', delimiter=',')
Ytrain = np.loadtxt('data/banana_Y_train', delimiter=',').reshape(-1,1)
```

In [3]:

```
def gridParams():
    mins = [-3.25,-2.85 ]
    maxs = [ 3.65, 3.4 ]
    nGrid = 50
    xspaced = np.linspace( mins[0], maxs[0], nGrid )
    yspaced = np.linspace( mins[1], maxs[1], nGrid )
    xx, yy = np.meshgrid( xspaced, yspaced )
    Xplot = np.vstack((xx.flatten(),yy.flatten())).T
    return mins, maxs, xx, yy, Xplot

def plot(m, ax):
    col1 = '#0172B2'
    col2 = '#CC6600'
    mins, maxs, xx, yy, Xplot = gridParams()
    p = m.predict_y(Xplot)[0]
    ax.plot(Xtrain[:,0][Ytrain[:,0]==1], Xtrain[:,1][Ytrain[:,0]==1], 'o',
color=col1, mew=0, alpha=0.5)
    ax.plot(Xtrain[:,0][Ytrain[:,0]==0], Xtrain[:,1][Ytrain[:,0]==0], 'o',
color=col2, mew=0, alpha=0.5)
    if hasattr(m, 'Z'):
        ax.plot(m.Z.value[:,0], m.Z.value[:,1], 'ko', mew=0, ms=4)
    ax.contour(xx, yy, p.reshape(*xx.shape), [0.5], colors='k', linewidths=1.8,
zorder=100)
```

In [6]:

```
# Setup the experiment and plotting.
Ms = [4, 8, 16, 32, 64]


# Run sparse classification with increasing number of inducing points
models = []
for index, num_inducing in enumerate(Ms):
    # kmeans for selecting Z
    from scipy.cluster.vq import kmeans
    Z = kmeans(Xtrain, num_inducing)[0]

    m = GPflow.svgp.SVGP(Xtrain, Ytrain,
                         kern=GPflow.kernels.RBF(2),
                         likelihood=GPflow.likelihoods.Bernoulli(), Z=Z)
    #Initially fix the hyperparameters.
    m.Z.fixed = True
    m.optimize(maxiter=20)

    #Unfix the hyperparameters.
    m.Z.fixed = False
    m.optimize(maxiter=200)
    models.append(m)
```

```
compiling tensorflow function...
done
optimization terminated, setting model state
compiling tensorflow function...
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done
optimization terminated, setting model state
```

In [7]:

```
#Run variational approximation without sparsity..
#..be aware that this is much slower.
m = GPflow.vgp.VGP(Xtrain, Ytrain,
                   kern=GPflow.kernels.RBF(2),
                   likelihood=GPflow.likelihoods.Bernoulli())
m.optimize(maxiter=2000)
models.append(m)
```

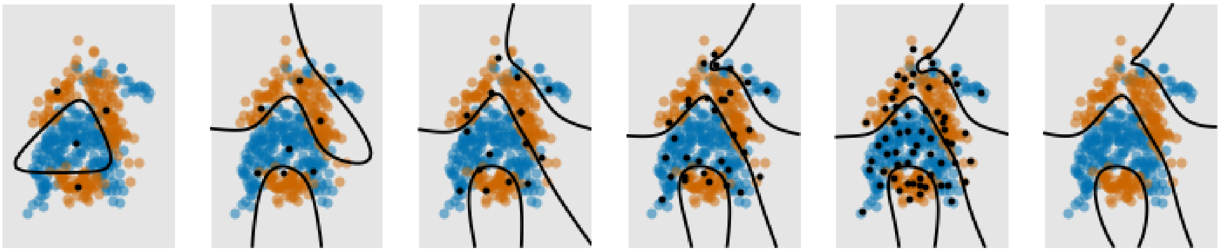
```
compiling tensorflow function...
done
optimization terminated, setting model state
```

In [8]:

```
# make plots.
fig, axes = plt.subplots(1, len(models), figsize=(12.5, 2.5), sharex=True,
sharey=True)
for i, m in enumerate(models):
    plot(m, axes[i])
axes[i].set_yticks([])
axes[i].set_xticks([])
```

Out[8]:

```
[]
```



In [9]:

```
models = models[:-3] + models[-1:]
```

In [ ]:

```
```