Bio-Inspired Artificial Intelligence - EMATM0029
Exercises - Neural Systems

TED talks

Watch the following TED talks related to neural systems, reflect on the potential and limitations of the approaches described:
`https://youtu.be/LS3wMC2BpxU?list=PLPwd13OaGbndtCwvT1hUieedttfKEbMmX`
`https://youtu.be/4OriCqvRoMs?list=PLPwd13OaGbndtCwvT1hUieedttfKEbMmX`

PS, here is our full youtube channel, please feel free to propose your favorite videos by email to sabine.hauert@bristol.ac.uk:
`https://www.youtube.com/playlist?list=PLPwd13OaGbndtCwvT1hUieedttfKEbMmX`

Brain initiatives

Know about important brain initiatives in the world. Browse the links below:

- Brain Initiative: `http://www.braininitiative.org/`
- Human Brain Project: `https://www.humanbrainproject.eu`

What is the goal - who are the partners - what is the methodology?

Visualising the brain

Explore the different scales at which brain modelling happens.

Browse the links below:

- Blue Brain Project: `http://bluebrain.epfl.ch/page-125411-en.html`
- Brain Map: `http://www.brain-map.org/`
- Human Connectome Project: `http://www.humanconnectomeproject.org/`

What are they modelling, where does the data come from, what is the scale?

Artificial Neural Networks

Download the code from the lecture (neuron.m, learning.m, and generatedata.m).

In generatedata.m, you'll see that teachinginputs contain 3 columns. The first is the input bias, the second is x1, and is randomly generated. The third is x2, also randomly generated. The teaching output was chosen to be x1*0.2+x2*0.3.

Run the following code:

```
[teachinginputs, teachingoutputs]=generatedata(100000)
[weights]=learning(teachinginputs,teachingoutputs)
neuron([-1 0.1 0.2],weights)
```

based on NN.
$\simeq (0.2 \times 0.5) + (0.3 \times 0.5) = 0.25$

Lots of outputs (100,000 to be spec.)
↳ mean is 0.2491

Similar

Does the output of the neuron give you the expected result?

What happens if you change the teaching output to x1*5+x2*3 and perform learning? Does the output of the neuron fit the teaching output? Hint: think about the output function of the neuron. What can you do to scale the output?

Change the teaching output to the following and perform learning.

```
teachingoutputs = [teachinginputs(:,2).*sin(teachinginputs(:,3))];
```

Does the output of the neuron fit the teaching output? How would you fix this?
Can you spot the line in the code that adjusts the weights of the network based on the error of the output? Do you understand how it works (see slides from lecture)?

Use matlab's predefined neural network toolbox to get a better fit for the data using hidden neurons. Prepare and run a new script called hidden.m that contains the following code:

```
%feedforward neural network with a single hidden layer with 10 hidden neurons
[teachinginputs, teachingoutputs]= generatedata(1000)
net = feedforwardnet(5);
net=train(net,teachinginputs',teachingoutputs');
view(net);
y = net(teachinginputs');
plot(teachingoutputs',y,'.');
```

You should see an identity function in the plot if the output of the trained neural network is similar to the teaching output. Why did the hidden layer help? How many hidden neurons do you need (try changing in the code)? What happens if the data is noisy and what should you do to avoid overfitting?

Read more about feedforward neural networks here:
`http://uk.mathworks.com/help/nnet/ref/feedforwardnet.html`

The matlab toolbox is introduced here:
`http://uk.mathworks.com/help/nnet/getting-started-with-neural-network-toolbox.html`.

Architectures

Choosing the right neural network architecture has a large impact on the success of the method. Draw neural network architectures that you believe could solve the following problems. Try to pick the simplest structure possible.

- controlling the speed of two wheels on a robot given the information on two light sensors so that the robot goes towards a light source.
- deciding if the sum of 6 numbers is above a given threshold.
- determining if an image is mostly black or white.

- recognising all hand-written letters of the alphabet as the intended letter.
- predicting if you are falling asleep using fitbit data.

Optional: Where to go from here

There are many tools available to run more advanced machine learning techniques, for example:
Tensorflow: `https://www.tensorflow.org/`
Caffe: `http://caffe.berkeleyvision.org/`
Mahout: `http://mahout.apache.org/`
OpenAI Gym: `https://gym.openai.com/`
Theano: `http://deeplearning.net/software/theano/`
Torch: `http://torch.ch/`
DeepLearning4K: `https://deeplearning4j.org/`
Weka: `http://www.cs.waikato.ac.nz/ml/weka/`

Some things to try: Install your own DeepDream Code:
`https://research.googleblog.com/2015/07/deepdream-code-example-for-visualizing.html`

Cool tutorial on how to play pong using OpenAI Gym:
`http://karpathy.github.io/2016/05/31/rl/`

Use TensorFlow to recognize hand written characters:
`https://www.tensorflow.org/tutorials/mnist/tf/`