Characterizing learning by simultaneous analysis of continuous and binary measures of performance

These programs accompany the paper

> Prerau MJ, **Smith AC**, Eden UT, Kubota Y, Yanike M, Suzuki W, Graybiel AM, Brown EN. Characterizing learning by simultaneous analysis of continuous and binary measures of performance. J Neurophysiol, 2009, 102: 3060-72

There are two sets of programs in two subdirectories called EMversion (described in the paper) and Bayesianversion (matlab-interfaced Winbugs code).

EM version

To run an example, start Matlab, move into the EMversion directory and type "runEMexample". The code loads data from "Data.mat" from the directory above it and creates a plot of reaction times, cognitive state and probability of a correct response. The learning trial is computed as the trial when the cognitive state is significantly above the initial state distribution. The significance value is set using the parameter `pcrit`.

There are two options for the initial conditions (`startflag`). With `startflag = 0`, the initial probability of a correct response is fixed at the value specified in `backprobg`. With `startflag = 2`, the initial conditions are estimated.

To input your own data just replace lines 7-9 in "runEMexample.m":

```
load ../Data3
N = Data3.N;        %binary responses
Z = Data3.Z;        %z is log(reaction time)
```

with your own binary data "N" and log(reaction time) data "Z".

Debugging notes

The EM algorithm is fairly robust on most reasonable data sets. If the EM algorithm does not converge (i.e. gives an error), one can toggle the `startflag` option (0 or 2), adjust the initial guesses for parameters, or switch to the Bayesian version below.

Bayesian version

Before the code can be run in Windows:

1. Install WinBugs from http://www.mrc-bsu.cam.ac.uk/bugs/

2. Check that line 52 in runBayesianexample.m correctly identifies the location of the installed WinBugs code e.g. 'C:/Program Files/WinBUGS14'.

   Note that for Windows 7 and Vista OS, there may be issues with write-permission to the Program Files directory so it is best to install in another directory.

3. Download "matbugs.m" into your directory from http://code.google.com/p/matbugs/ (written by Kevin Murphy and Maryam Mahdaviani, August 2005).

To run an example, start Matlab, move into the Bayesianversion directory and type "runBayesianexample". Again, there are two options for the initial conditions (`startflag`). With `startflag = 0`, the initial probability of a correct response is fixed at the value specified in backprobg. With `startflag = 2`, the initial conditions are estimated.

To input your own data just replace the following lines 9-11 in runBayesianexample.m:

```
load ../Data
n = Data.N;        %binary responses
z = Data.Z;        %z is log(reaction time)
```

with your own binary data "n" and log(reaction time) data "z".

With MCMC it is important to check that the chains have converged. One way to do this is to visualize the chains within Winbugs by changing the option on view to

Debugging notes

If the code won't run there may be some practical issues to address 1) check that you're not just running the student version of Winbugs (-the full version requires downloading a key) and 2) check that the subdirectory path to your files isn't very long – if it is more than 50 characters the path is too long so you need to shorten the directory names.

Trap errors sometimes occur within WinBugs. Often for the time series models used here it is caused by the choice of prior on the precision of the random walk for the binary data (e.g. taunu ~ dgamma(10, 1) is used in the models presented). One way to help reduce trap errors is

the increase the mean of the precision to say dgamma(20, 1). This essentially reduces the variance of the prior and improves stability of the sampling, at the cost of using a less uninformative prior.

Comparison between EM and Bayesian versions

The two versions give slightly different results because the EM version uses an empirical Bayes approach whereas the other approach is fully Bayesian.

An advantage of the Bayesian approach is that modifications to the code are easy to make: it just requires making changes to the short codes "Mixedfilterv1.txt" or "Mixedfilterv2.txt". Changes to the EM code require re-deriving the equations.

However, the EM algorithm runs faster on a desktop computer than the Bayesian algorithm. This is not a serious issue until the number of trials gets approximately over 3000.

There are more details on the Bayesian and empirical Bayes approaches in "The Tutorial" written for our behavioral learning algorithms available in the zip file at http://www.neurostat.mit.edu/behaviorallearning.

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