Homework #5 (100 points)

207.547 Seminar in Experimental Psychology: Computational Modeling
Spring 2018
Due: Thursday, May 24th, at 11:59 pm

1. (30 pts). Simulation and parameter recovery using a simple reinforcement learning model

(1) **(10 pts)** Find the `simulate_hw5_model1.R` file and generate simulated data (`simul_data_hw5_model1.txt`) using the code and its default settings (`num_subjs` = 30, `num_trials`=300).

(2) **(20 pts)** Using `hw5_model1.stan` and `hw5_model1.R` files,
(2a) (**5 pts**) Find the posterior distribution of individual and group (hyper) parameters.
(2b) (**15 pts**) Draw a scatterplot of true parameters and estimated parameters (x axis: true individual parameters, y axis: individual posterior means). Add error bars along the y-axis (error bars = +-1 SD of individual posterior distributions). Check if true parameters are relatively well recovered.

2. (**20 pts**) Comparing the outputs from hierarchical and non-hierarchical Bayesian models.
(1) (**5 pts**) Like you did for HW#4, program your R and Stan codes that will estimate individual posterior distributions of alpha and beta (a non-hierarchical version). Use the same simulated data generated in Question#1.
(2) (**10 pts**) Draw a scatterplot of true parameters and estimated parameters (x axis: true individual parameters, y axis: individual posterior means). Add error bars along the y-axis (error bars = +-1 SD of individual posterior distributions).
(3) (**5 pts**) Do you see a noticeable difference in the two scatter plots you generated in Question#1(2) and Question#2(2)? Try to explain why.

3. (**30 pts**) "Shrinkage" in hierarchical Bayesian data analysis
(1) (**10 pts**) In the `simulate_hw5_model1.R` file, set `num_subjs` = 200, `num_trials`=100 and generate 200 fake subjects' data.
(2) (**10 pts**) Find the posterior distribution of individual and group (hyper) parameters (**warning: MCMC sampling may take a long time**).
(3) (**10 pts**) Draw a scatterplot of true parameters and estimated parameters (x axis: true individual parameters, y axis: individual posterior means). Add error bars along the y-axis (error bars = +-1 SD of individual posterior distributions). Check if true parameters are relatively well recovered.
(4) (**Bonus point: 10 pts**) Do you notice "shrinkage" in one parameter but not so much in the other parameter? Can you explain why?

4. (**Bonus question, 30 pts**)

Modify provided Stan and R codes so that we can allow two learning rates in the reinforcement learning model. `alpha_pos` → learning rate when a prediction error is zero or above. `alpha_neg` → learning rate when a prediction error is less than zero. Use the following settings for generating true parameters:

```
simul_pars = data.frame(alpha_pos = rnorm(num_subjs, 0.20, 0.08),
                        alpha_neg = rnorm(num_subjs, 0.30, 0.10),
                        beta = rnorm(num_subjs, 2.00, 0.70),
                        subjID  = 1:num_subjs)
```

Also, set `num_subjs` = 30, `num_trials`=100.

(1) (**5 pts**) Find the posterior distribution of individual and group (hyper) parameters.
(2) (**5 pts**) Draw a scatterplot of true parameters and estimated parameters (x axis: true individual parameters, y axis: individual posterior means). Add error bars along the y-axis (error bars = +-1 SD of individual posterior distributions). Check if true parameters are relatively well recovered.
(3) (**10 pts**) In the `simulate_hw5_model1.R`, change `num_trials`, `pr_correct_option1`, and `pr_correct_option2` (lines 12-13) like the following and re-generate simulated data:

```
num_trials <- 300
pr_correct_option1 <- 0.3
pr_correct_option2 <- 0.6
```

Find the posterior distributions and draw a scatter of true parameters and estimated parameters (x axis: true individual parameters, y axis: individual posterior means). Add error bars along the y-axis (error bars = +-1 SD of individual posterior distributions).

(4) (**10 pts**) Do you notice any difference between what you found in (2) and (3)? Try to explain what made the difference.

Attach all your R/Stan program. Please generate a single PDF file with all the outputs.