PSET1 - Bi-matrix Game Human Behavior Forecast Contest

CS236r (Spring 2020)

Due: March 24th

1 Instruction

In the first month of our course, we have discussed several papers developing theories, models and machine learning techniques to predict human behavior in economic environments. Though machine learning technologies have proved their power in a vast range of prediction scenarios, their success has heavily relied on the amount of proper training data they can get. Clean human behavior data in a certain game environment is a scarce resource, as it has to be collected from in well-controlled human-subject experiments. Therefore, theories and models developed from insights of human behaviors are valuable and will effectively help us predict human behavior in certain scenarios with limited observations.

In this problem set, you are going to take part in a contest and make real forecasts about human behavior in bi-matrix games. You can utilize any human behavior theories and models or machine learning techniques to make forecasts and win the contest.

2 Task

We have a human behavior dataset on 250 3×3 bi-matrix games. Each 3×3 bi-matrix game is represented by a payoff matrix:

$$\begin{bmatrix} r_{11}, c_{11} & r_{12}, c_{12} & r_{13}, c_{13} \\ r_{21}, c_{21} & r_{22}, c_{22} & r_{23}, c_{23} \\ r_{31}, c_{31} & r_{32}, c_{32} & r_{33}, c_{33} \end{bmatrix},$$

where $r_{i,j}, i, j \in \{1, 2, 3\}$ is the payoff of the row player if the row player plays action i and the column player plays action j, and $c_{i,j}$ is the corresponding payoff for the column player.

Human subjects were asked to play the bi-matrix games by choosing one of the three actions as a row player or a column player. Each human player plays a game only once. For each game, the frequency of each row action being chosen by the initial plays of these participants have been recorded. We denote the frequency for row player' action i being chosen as $f_i \in [0, 1]$ for any $i \in \{1, 2, 3\}$. We denote the most frequently chosen action among the three actions as $\mathsf{Action} \in \{1, 2, 3\}$.

We have divided the datasets into two parts, training data and test data. **You are asked to form a team of two to predict f_1, f_2, f_3 and Action of a game given the payoff matrix for games in the test data.**

Notice that

- You can use any theory and models, including your own opinions about how human make decisions.
- You are not required to use any machine learning methods, especially neural networks, but you can definitely use them at your will, including any off-the-shelf libraries or packages, e.g., sklearn, scipy, pytorch.
- There is a bunch of human behavior models you can utilize, e.g., Nash equilibrium, level-k reasoning, quantal response model, risk preference, and simple heuristics.
- You can use the training data to compare and evaluate your own approaches, select parameters for your models or train your machine learning predictors.

You should use either Python or Matlab to write your code. You can use any editor you like, e.g., Jupyter notebook when you develop your code. If you have to use other languages, write to TA (jtwangac@gmail.com). We do not expect you to give a predictor with more than 100 lines for the main algorithm.

3 Grading Policy

This work will be evaluated by two parts.

- **Methodology (50%).** If you use purely behavior models, we will evaluate how you study the improvement of the behavior models w.r.t. certain benchmarks, what comparison you have made, what changes to the model or new model you have tried if there is any. If you use mainly machine learning approach, we will evaluate what adaption you have made to the machine learning predictors or the training processes, etc. Overall, we will evaluate your work by what insights about human behaviors in 3X3 bi-matrix game you have gotten in your work and by how well you support your insights using the data and your experiments.
- **Forecast Accuracy (50%).** we will evaluate with the following two metrics. Let $\hat{f}_i \in [0, 1]$ be your prediction for f_i and $\hat{\mathsf{Action}} \in \{1, 2, 3\}$ be your prediction for Action of a single game.

  1. Quadratic distance of the frequency distribution:

  $$Q = (\hat{f}_1 - f_1)^2 + (\hat{f}_2 - f_2)^2 + (\hat{f}_3 - f_3)^2$$

  2. Accuracy in predicting the most frequently chosen action :

  $$A = \mathbb{1}\left(\hat{\mathsf{Action}} == \mathsf{Action}\right)$$

  We will take the mean of these two metrics across test games. Any team beats the random guess ($\bar{A} = 0.33$) will get 80% points in this part. Any team beats the uniform pure-strategy Nash equilibrium ($\bar{A} \approx 0.5$) will get all points in this part. The top three teams in metric Q will be announced and get additional 10% points for this assignment.

4 Datasets

Our dataset has been divided into parts, training data and test data. For each part, there are two files

- Training data (250 games)
  - hb_train_feature.csv (released)
  - hb_train_truth.csv (released)
- Test data (200 games)
  - hb_test_feature.csv (released)
  - hb_test_truth.csv (reserved for test)

In hb_*_feature.csv, each entry is

$$[r_{11}, r_{12}, r_{13}, r_{21}, r_{22}, r_{23}, r_{31}, r_{32}, r_{33}, c_{11}, c_{12}, c_{13}, c_{21}, c_{22}, c_{23}, c_{31}, c_{32}, c_{33}]$$

for a single game.

In hb_*_truth.csv, each entry is

$$[f_1, f_2, f_3, \mathsf{Action}]$$

for a single game.

Games are listed in the same order in both files in each part.

5 Final products and formats

Your final products should include two parts.

1. Report: you should submit a report in single-column pdf of at least 1 full page, documenting the follows:
   - The main approach you used.
   - Any attempts you tried and any comparison you made.
   - Any discovery that interests you.
   - Q and A scores of your final approach on the training data.
2. Code and forecasts: you should submit a .zip. Please include:
   - a file named as hb_test_pred.csv, which is in the same form of hb_*_test.csv. We will compare your file w.r.t. hb_test_truth.csv using the aforementioned two metrics.
   - a file named as main_test.py or main_test.m. This file should be able to run by command "python main_test.py" under the current directory, or by a single click, and should generate the same file hb_test_pred.csv. Therefore, please write file names "hb_test_feature.csv" and "hb_test_pred.csv" directly into your code.
   - Any file that is required to run main_test.py or main_test.m, excluding the off-the-shelf libraries or packages.

Submission instruction: When making a submission, only one member of each team needs to submit the final product, and please include your report pdf into the .zip file where your code can be run.

6 Tips

- For Python users, you can use pandas to read and write .csv
- For Matlab users, you can use

  ```
  M = readtable('hb_train_feature.csv');
  M = M{:, :};
  ```

  to read our .csv file into a Matlab matrix.