Bayesian Model vs Human Prediction In a conditioned game of Rock-Paper-Scissors

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Final Project Report

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*Abstract*— the entirety of this project is centered on a fascinating research, geared at comparing human reasoning with a mathematical models of prediction – Bayesian Modeling.

*Index Terms*—Research, web-game, human modelling, Baye’s theorem, Markov chain, state transition, stability.

# Introduction

The aim of this project is to study the accuracy of Bayesian inference models, when compared to human predictions.

In an attempt to make the approach friendlier towards the average person, the result gathering mechanism for this research was made in the form of a web-game.

Once the web-game was built, the results were then formatted, and stored in a remote data-base. On a daily basis, the request were process, each time comparing a players predictions to that of a Bayesian Model.

At the end of this comparison phase, some plots are drafted, showing the running average human model prediction against the mathematical inference model.

Subsequent sections will elaborate more on all the aforementioned procedures.

# Information Gathering Phase

The greatest hindrance this project faced in this early beginnings was its lack of a user friendly information gathering mechanism. Initially, this phase was made to use an interactive telnet interface. Not many users logged into the server, and of the few who logged in, even fewer found the experience pleasant,

Because the availability of a large enough dataset was imperative for the project, it became a top priority to make the data gathering as easy and friendly as possible.

The first boost in this phase, was changing the approach from being imperative (a set of questions with little or no background), to narrative – letting the reader getting absorbed into an interesting story line, associating him/her to the role of main character, and adding some humor to further render the experience agreeable.

Though that was a boost, the project still did not get a tremendous amount of participation as the technology needed was still telnet interface – the bottle neck.

Though it was a LOT of work and extra research, the project was moved from a telnet interface to a web-based interface.

The greatest advantage offered by web-based interfaces is that they are not OS-restricted, nor do they require any specialized piece of software (e.g. java JRE, python interpreter, c/c++ compiler etc.). The website could we found at <http://mj-server.mit.edu/6.804/play>.

Even still on its very early release, the website attracted a lot more users, and hence was very promising. Because of its early success, the web-based game interface was then completely moved over from telnet, to html and javascript. The server however, was built on Django python.

As this still its natal periods (built 1.0 completed on 12/16/2013), the website might go out of service for maintenance purposes from time to time.

That concludes the information gathering mechanism for this project. The subsequent section shall discuss the setup through with we condition the user, before playing the game.

# The Conditioning

In an effort to compare apple-to-apple, the human user was first subjected to all the data, which the Mathematical model is built on. This was important, as it ensured both the human and the Mathematical models are based on the same priors.

Because this was a dense level of information, it was important to pass this message in a smooth and gentle fashion.

In that light, a story was built, to facilitate the uptake of all that information. As you user opens the webpage, he/she is greeted with the following passage

“

*Extra-Terrestrial Rock Paper Scissors*

*Setup*

*You are a science student, who is always fascinated by outer space, and are always wondering whether WE are alone in the universe. As current technology cannot help you find your answer, you fall back to superstition, and scheme out a very 'clever' plan.*

*For generations now, humans have it that, making a wish to a shooting star, will grant that wish. Because you probably cannot wait for technology to advance (as it might take thousands of years), you will rather wait for the next shooting start. So you begin your Star Hunt!*

*Every night, you camp in on the savanna grass field, just contemplating the stars, and hoping to find one that 'shoots'.*

*Sure enough, your patience paid off, and one night, you spotted a shooting star.*

*You did not only want to know if WE were alone, but also, how intelligent the other species out of earth were if they existed. A way you thought of to test their intelligence, was to play an IQ game with them. Short on time, you could only think about Rock-Paper-Scissors (RPS). So you went on:*

*"Oh shooting star, I wish you take me to the most technologically advanced extraterrestrial specie in the Universe, for just enough time for me to finish playing some games of Rock-Paper-Scissors"*

*Of course, you didn't expect it to work but guess what... IT DID!*

*You got teleported into the star, and was heading towards Planet MIT-21.*

*On the way however, the star tells you it will bring you to the sole planet which knows about RPS. You, all curious, ask for more details on the planet. The star gladly summarizes the following to you:*

*"There are 4 main groups of peoples on planet MIT-21:*

*the Rockers, who choose Rock 70% of the time, and the other 2 randomly,*

*the Paperers, who choose Paper 80% of the time, and the other 2 randomly,*

*the Scissorers, who choose Scissor 90% of the time, and the other 2 randomly, and*

*the Normals, who have no preference. FURTHERMORE*

*MIT-21 inhabitants can switch consciousnesses amongst themselves. So you might be playing with a Rocker at the start, but that Rocker switches consciousness with a Paperer, at some point in the game. The switch happens according to the following affinity table: (the higher the affinity, the more likely it is for the switch to occur)*

*MIT-21 Affinity Table*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  |  | ***To*** |  |  |
|  |  | *Rocker* | *Paperer* | *Scissorer* | *Normal* |
|  | *Rocker* | *60%* | *15%* | *15%* | *10%* |
| ***From*** | *Paperer* | *10%* | *60%* | *20%* | *10%* |
|  | *Scissorer* | *15%* | *15%* | *60%* | *10%* |
|  | *Normal* | *1%* | *1%* | *1%* | *97%* |

*After getting all the information, the star drops you off at a bar, and where you challenge a loner to a friendly game of RPS.*

*Scenario R*

*You start the game, and he opens tells you he is currently a Rocker.*

*>>> Game play here <<<*

*Scenario P*

*You start the game, and he opens tells you he is currently a Paperer.*

*>>> Game play here <<<*

*Scenario S*

*You start the game, and he opens tells you he is currently a Scissorers.*

*>>> Game play here <<<*

*Scenario N*

*You start the game, and he opens tells you he is currently a Normal.*

*>>> Game play here <<<*

… After all the game plays

*Based on the results above, could you infer what consciousnesses you were dealing with at each round,*

*eg RRRPPNN for Rocker from round 1 - 4, Paperer from round 5 to 6, ...*

*”*

The aim is to submerge the reader into a nice a story line, while still giving enough data to match all the Mathematical model knows about.

The numbers in the chart were to simulate two very important concepts, which are taught in 6.804: Bayesian inference, and Markov chain – with state transitions and stable forms, all in hidden a hidden Markov Model.

The following section, will detail reasoning behind the numbers, and what the Mathematical model stated.

# Mathematical Models

## The Bayesian Model

Here below was the Bayesian model (NB: this could be pulled directly from the setup story)

With this model, the mathematical model

* of Scenario R which started with prior of a Rocker, and assumed no “consciousness switch” was stable around R,
* while that of Scenario P, which started with prior of a Paperer, and assumed no “consciousness switch” was stable around P,
* while that of Scenario S, which started with prior of a Scissorer, and assumed no “consciousness switch” was stable around S,
* while that of Scenario N, which started with prior of a Normal, and assumed no “consciousness switch” was uniformly distributed about all 3 options.

The idea was to have groups having such tendencies, to add some variation to the model, and hence introducing a bases for comparison between the 2 models.

## The Markov chain Model

Here below was the Markov model (again, this is a direct read from the description):

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  | *Rocker* | *Paperer* | *Scissorer* | *Normal* |
|  |  |  |  |  |  |
| *Rocker* |  | *60%* | *15%* | *15%* | *10%* |
| *Paperer* |  | *10%* | *60%* | *20%* | *10%* |
| *Scissorer* |  | *15%* | *15%* | *60%* | *10%* |
| *Normal* |  | *1%* | *1%* | *1%* | *97%* |

With the above model, the early generations (iterations) did not show any particularly strong preference for any of the groups, but at later generations however, after several iterations, the model started to experience a very high stability at the *“Normal”* group.

This makes sense because, all groups except the Normal group, have a 10% chance of transitioning to a normal group, while the Normal group basically serves as trapping group. Once in the Normal group, the total probability of leaving is just 3%.

This was the expected answer when the user was asked the last concluding question:

*Based on the results above, could you infer what consciousnesses you were dealing with at each round,*

The following section will summarize the results we obtained from over 100 user records.

# Results

First off, it was important that not even the developer of the project knew about the sequence before they are generated. As a result the entity of the algorithm made use of random inbuilt for all sensitive tasks.

For an overview of the setting up phase, readers are advised to skim through the <https://github.com/JohnMofor/6.804-final-project/blob/master/erps/play/models.py>

The following are some of the most important take-home notes on the results we obtained:

* The mathematical model did a pretty good job at matching the human predictions on the stable state of the Markov chain i.e. after several iterations. As of the data set processed on 12/20/2013, it has a 98% accuracy.
  + At this point, one could argue that the human subjects who contributed to the -2% off a perfect accuracy were wrong in their analysis.
    - Though theoretically true, the goal of this research, was to find the percentage match only. It is a fine thing to let the users have their say.
* As well, the mathematical did pretty good job at discerning the relative frequencies of occurrence of “R”,”P”, and “S” in each scenario. Though the users did not get exact accuracies in sequence order, but the overall frequency they predicted matched the overall frequencies of both the model and the actual data.
* Unfortunately, the model did not do well at matching the users prediction on the state transitions (22.7%). This is quite explicable as both the user and model had no way of detecting switches with 100% certainty, especially the switches into or out of group N. As a result, both parties are bound to mismatch.

Those represent the highlights of all the results this research produced.

# Copyright Forms

The project paper used an online template for conference format documents, and requires some paper-work before submission. To that, it will be vital to point that, THIS IS MEANT AS A CLASS PROJECT AND NOT FOR PUBLICATION.

# Acknowledgment

The 6.804J staff of Fall of 2013, for all their help, in making me understand a lot of very fun concepts, giving me enough knowledge to make this project happen.

Fun Fact

This project took over 60 hours, and more than 1500 lines of code in total.