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A CALIBRATION MODEL FOR BOT-LIKE BEHAVIORS IN AGENT-BASED ANAGRAM GAME SIMULATION

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ABSTRACT

Experiments that are games played among a network of players are widely used to study human behavior. Furthermore, bots or intelligent systems can be used in these games to produce contexts that elicit particular types of human responses. Bot behaviors could be specified solely based on experimental data. In this work, we take a different perspective, called the Probability Calibration (PC) approach, to simulate networked group anagram games with certain players having bot-like behaviors. The proposed method starts with data-driven models and calibrates in principled ways the parameters that alter player behaviors. It can alter the performance of each type of agent (e.g., bot) action, per player, in group anagram games. Further, statistical methods are used to test whether the PC models produce results that are statistically different from those of the original models. Case studies demonstrate the merits of the proposed method.

1 INTRODUCTION

Networked games—games or experiments that assign human subjects as nodes in graphs and interaction channels between pairs of humans as edge—are used in many different contexts like economics, anthropology, and social sciences for various studies. The focus of this work is a networked anagram game (Cedeno-Mieles et al. 2020), where players can share their provided alphabetic letters with their neighbors to form as many words as possible within the time limit. Existing work has used data from over 200 experiments to build statistical models of game player behavior (Liu et al. 2022). The goal of this study is to produce behaviors for players that are not observed in the experimental data, especially when the players are assisted by intelligent systems.

In this work, a new model called the Probability Calibration (PC) model is developed to generate player behaviors not observed in the experiments. This model forms the basis for a new agent-based simulation (ABS) approach, called PC-based ABS. This work introduces three main contributions to the field of networked anagram games (NGrAGs):

- **Novel Modeling Approach**: A Probability Calibration (PC) model is proposed to extend player behavior beyond what is captured in existing data. This model incorporates calibration parameters that allow for the adjustment of player actions, making agent-based simulations more flexible. It also accommodates varying degrees of intelligent system utilization.
- **Evaluation Methodology**: Functional Analysis of Variance (FANOVA) is used to assess the significance of the new models in terms of player performance. This provides insights into how different calibration parameters can lead to significant changes in player behavior.
- **Simulation-Based Case Study**: The work includes a case study using both reference and proposed PC models to examine the dynamics of player behavior. The study reveals interesting findings, such as how modifying certain probabilities can lead to more words being formed by agents, thus potentially promoting collective identity among players.

2 METHODS

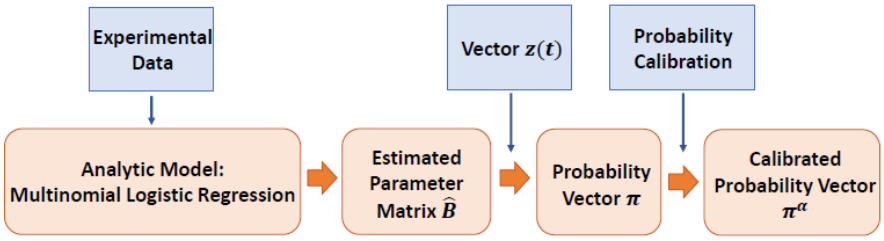

Figure 1: Flowchart for the probability calibration (PC) model to adjust the probability of each action, at every time step.

The key idea of the proposed PC model is to first use an analytic model to determine transition probabilities based on the experiment data and the player's historical behaviors, and then calibrates these probabilities to account for the influence of intelligent systems as shown in Figure 1. This offers greater flexibility, especially when intelligent systems have a significant role in player decision-making, as calibration parameters can be adjusted accordingly.

3 AGENT-BASED SIMULATION RESULTS

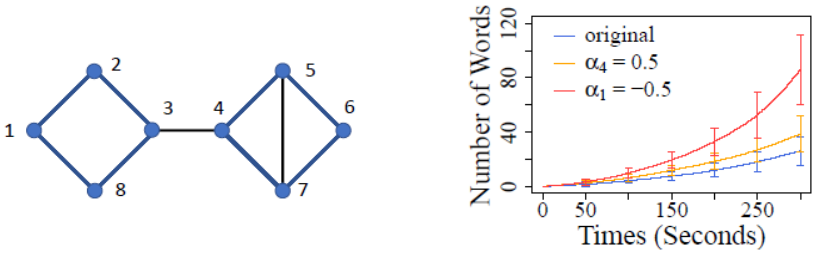

Figure 2: (a) Anagram game network for simulation. (b) Average number of words formed using the PC approach for nodes 3.

Simulation results are provided for a NGrAG with eight players as shown in Figure 2(a). Figure 2(b) illustrates the impact on node 3 when decreasing the probability of idling by 50% ($\alpha_1 = -0.5$) and increasing the probability of forming words by 50% ($\alpha_4 = 0.5$).

4 CONCLUSION

The work introduces a Probability Calibration (PC) model to simulate group anagram games featuring bot-like player behaviors. Starting with data-driven models, the PC approach adjusts player behavior through calibrated parameters. The approach is versatile, applicable to other models governed by probabilities. Future work will explore more complex calibration parameters and evaluation methods.

REFERENCES

Cedeno-Mieles, V., Z. Hu, Y. Ren et al. 2020. "Networked Experiments and Modeling for Producing Collective Identity in a Group of Human Subjects Using an Iterative Abduction Framework". *Social Network Analysis and Mining (SNAM)* 10.

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