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Uncertainty dynamics in games and its implication to entertaining activity assessment

by

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Absract

Research Content

Games are embedded and grown with the human culture even before human society emerged (Huizinga1980). With artificial intelligence (AI) advancement, games are gradually regarded as an accessible way to simulate human society and explore more profound insights into human science. The human mind, often considered synonymous with consciousness, has been called the last frontier of science (Herbert 1993). Human mind is as mysterious as universe, where the physics-in-mind could be reasonably related to physics in nature. What this dissertation interested, is probing into a deeper sight of the mechanism of physics in mind using game and game-liked activities as the benchmark. This thesis is about establishing the correlation between the psychological model and the information model, incorporating concept from physics, which can help people to better understand the human life.

Research Purpose

This dissertation focuses on the uncertainty dynamics in games and its implication to analyzing entertaining activity. (1) Firstly, the human player-versus-human player rules based card game is firstly discussed, which can be competed by multiple players at the same time but can maintain the same competition for each player. This study set experiments and simulate DouDiZhu self-play. The preliminary simulation results revealed that three-player DouDiZhu is perfectly refined with sophistication, entertainment, and fairness on the measurement of game refinement at $DouDiZhu[(3, 1, 2)(20, 17, 17)]$. Cooperation is essential to maintain the fairness and uncertainty of both sides. (2) It then explores single-player arcade games where human players simply compete against the rules of the game and can significantly observe individual player skill improvement through practice. Four popular arcade games are selected and analyzed as benchmark. The application scope of the theory of motion in mind is expanded by incorporating relative velocity and resultant force. A feasible scheme of potential growth rate is proposed to measure the single-agent arcade games that were unquantifiable before because these kinds of games have no definitive game length. It found jerk's dynamics would affect game's uncertainty to a great extent and is the essential factor to sustain the game's engagement. (3)Then we discuss idle games, which are not competitive and even encourage players not to participate in the progress of the game. Uncertainty is the expectation to closing the gap

between income and cost in idle game domain. It also found that not only the equations of motion in mind model would help to analyze the idle games, but also the derivatives of the functions are also able to. Motives in mind (E_q) and predictive motion tendency ($\vec{p_2}$) are found to be the most important parameter when applied to the entertainment without much interaction. Moreover, long-term jerk was found able to maintain the freshness to the player. Synchronization can also help to maintain the engagement of the player.

From chapter to chapter, the model of motion in mind is also established, optimized its range, and evolved into a relative sophisticated shape. Taking different games and recreational activities as objects and using the construction of physical models in the mind as media, this study explores the effects of dynamic changes of uncertainty on the entertainment and attraction of games and recreational activities. Through the physical modeling of the motion in mind, this dissertation innovatively constructs the operation mode of the human mind world, provides a brand-new understanding and angle for the study of either human beings themselves or the nature of entertainment in different areas of the motion in mind model and is meaningful to establish entertainment science.

Keyword: *Game; Entertainment; Uncertainty; Information dynamics; Engagement; DouDiZhu; Arcade; Idle game*

Research Accomplishment

Journal Papers and Book Chapter

1. Gao Y., Li, W. , Xiao, Y., Khalid, M.N.A., Iida, H., Nature of Attractive Multiplayer Games: Case Study on China's Most Popular Card Game - doudizhu, Information, 2020, 11(3): 141, 2020.

2. Gao Y, Khalid M N A, Umi Kalsom Yusof, H.Iida, Coopetition in Solving Combinatorial Optimization Problem: Application to the Industrial Assembly Line Balancing Problem. TEST Engineering & Management, vol. 82, pp.11992-12000,2020.

1. Gao Y., Li W, Khalid M N A, Iida, H., Quantifying attractiveness of incomplete-information multi-player game: case study using doudizhu. In: Alfred R., Lim Y., Haviluddin H., On C. (eds) Computational Science and Technology. Lecture Notes in Electrical Engineering, vol 603. Springer, pages 301-310, 2019.

2. M. N. A. Khalid, Umi Kalsom Yusof, Yuexian GAO, H. Iida. Coopetition in Solving Combinatorial Optimization Problem: Application to the Industrial Assembly Line Balancing Problem. In: Alfred R., Lim Y., Haviluddin H., On C. (eds) Computational Science and Technology. Lecture Notes in Electrical Engineering, vol 603. Springer, 2019.

3. Gao Y. "Construction of Popularization Space for Popular Science Reading", Reading Promotion of Science Popularization, National Library of China Publishing House, 2019.

4. Gao, Y. Doudizhu Tournament on the 2019 Computer Olympiad. ICGA Journal, vol.42, no.1, pp.1-3,2020.

Presentations at international academic conferences

1. Gao Y., Li W, Khalid M N A, Iida, H. Quantifying attractiveness of incomplete-information multi-player game: case study using DouDiZhu. The Sixth International Conference on Computational Science and Technology(ICCST2019),48, Kota Kinabalu, 8.2019.

2. Gao Y, Khalid M N A, Umi Kalsom Yusof, H. Iida. Coopetition in Solving Combinatorial Optimization Problem: Application to the Industrial Assembly Line Balancing Problem. The Sixth International Conference on Computational Science and Technology(ICCST2019), 18, Kota Kinabalu, 8. 2019.

3. Gao Y, Gao N, Khalid M N A, Iida, H. Finding Flow in Training Activities by Exploring Single-Agent Arcade Game Information Dynamics. The 19th International Federation for Information Processing – International Conference on Entertainment Computing (IFIP-ICEC2020), 17, Xian, 11. 2020.

Other

- JAIST Heisei 31th year research site formation support business: budding research support. A new theoretical construction of entertainment science - science as a ride for the world of mind.