

Contents

Abstract	i
Acknowledgments	iv
1 Introduction	1
1.1 Chapter Introduction	1
1.2 Problem Statement and Research Questions	2
1.3 Research Objectives	4
1.4 Thesis Structure	5
2 Related Works	8
2.1 Chapter Introduction	8
2.2 Game Refinement Theory and Motion in Mind Concept	8
2.2.1 Motion in mind model	10
2.2.2 Jerk and comfort in mind	13
2.3 Card Games as Testbed in This Study	15
2.4 Perfect Information Game and Imperfect Information Game	17
2.4.1 Perfect information game	17
2.4.2 Imperfect information game	18
2.5 Reward Frequency in Reinforcement Learning	19
2.5.1 Influence of reward frequency in gaming	19
2.6 Chapter Conclusion	20

3	A Computational Game Experience Analysis via Game Refinement Theory	22
3.1	Chapter Introduction	22
3.2	Measurement of Play in Games	25
3.2.1	Player Experiences in Games	25
3.3	Player Psychology in Games	27
3.4	Game Refinement Theory and Its Development	29
3.4.1	Game Refinement Theory and Its Development	29
3.4.2	Jerk and Comfort in Mind	30
3.5	Gamified Experience From Metaphysical Perspectives	34
3.5.1	Basketball	36
3.5.2	Soccer board	38
3.6	Physics and Psychophysiology Processes in Games	40
3.6.1	Interaction Dynamic	41
3.6.2	Game Playing Experience and Flow Theory	43
3.6.3	Conceptual Basis of Motion in Mind	47
3.6.4	Limitations and Future Works	52
3.7	Chapter Conclusion	53
4	Implications of Jerk's On The Measure of Game's Entertainment: Discovering Potentially Addictive Games	55
4.1	Chapter Introduction	56
4.2	Previous work	58
4.3	Analysis of Card Games	61
4.3.1	Suits irrelevant card games: Wakeng and Doudizhu	62
4.3.2	Suits relevant card games: Big Two, Winner, and Tien Len	65
4.4	Proposed Computational Models	66
4.4.1	Game progress model	66

4.4.2	Motion in mind model	69
4.4.3	Experimental design	72
4.5	Computational Results	74
4.5.1	Result analysis of DouDiZhu	74
4.5.2	Result analysis of Wakeng	77
4.5.3	Result analysis of suits-relevant card games	77
4.5.4	Result analysis of fixed AI levels	79
4.6	Discussion	81
4.6.1	Comparison on different game complexities	81
4.6.2	<i>GR</i> and <i>AD</i> relative to addictive situation	84
4.7	Chapter Conclusion	89
v		
5	The Impact of Performance Degree on Players: Exploring the Dynamics of Player Engagement and Enjoyment in Game Process	92
5.1	Chapter Introduction	92
5.2	Related Works	93
5.2.1	The meaning of playing performance	94
5.2.2	The acceleration a_k of different kinds of players	95
5.2.3	The balance of perfect player and imperfect player from the perspective of potential energy	95
5.2.4	Exploring optimal rounds for distinguishing real strength	97
5.3	Performance Degree (k): In-Depth Analysis	100
5.3.1	The risk rate m and performance degree k	100
5.3.2	The explanation of the correspondence system of m and the maximum acceptable performance degree k	100
5.3.3	Comparison of motion in mind measures based on performance degree k	103

5.4	Dynamic Interaction between Performance Level k , Reward Frequency N , and AD	107
5.4.1	Performance level k and reward frequency N	107
5.4.2	Performance level k and AD	108
5.4.3	Reward frequency N and AD	109
5.4.4	The difference between perfect information games and imperfect information games	115
5.5	The influence of ratio ϕ (GR/AD)	116
5.6	Chapter Conclusion	123
6	Conclusion	126

List of Figures

2-1	An illustration of move selection model based on skill and chance . . .	10
2-2	Objective and subjective reinforcement when $k = 3$	13
2-3	The cross point between the line with velocity v , curve with acceleration a and curve with jerk j . t_1 ; t_2 and t_3 represent the bound for effort, achievement, and discomfort, respectively.	15
3-1	The cross point between the line with velocity v , curve with acceleration a and curve with jerk j . t_1 ; t_2 and t_3 represent the bound for effort, achievement, and discomfort, respectively.	32
3-2	The cross point between the curves of the velocity v , acceleration a , and jerk j , where such a cross point describes the comfortable moment of the basketball game. After the cross point, it can be observed that with enough training and skill, achieving rewards becomes easy. However, the feeling of discomfort will also be higher due to boredom and insufficient challenge.	38
3-3	Using board game to play soccer	39
3-4	Using a game tree model to visualize the scoring process	41
3-5	<i>Challenge vs. Skill, illustrating the "flow" region</i> Source: English Wikipedia. https://en.wikipedia.org/wiki/File:Challenge_vs_skill.jpg . . .	45
3-6	The description of game process using Δ scores	45

3-7	The description of Flow theory using the game-playing process to associate the context of the expected experience when playing, based on self's (ability) and opponent's (challenge) score	46
3-8	The analysis of motions in mind based on dynamical scores gap	49
3-9	An example of the dynamic interactions and game-playing experience of one game process based on its association with the Flow theory	52
4-1	Objective and subjective reinforcement when $k = 3$	72
4-2	The tendency of GR and AD based on the ability level of sophisticated card games	76
4-3	The tendency of GR and AD based on the ability level of classical card games	79
4-4	The tendency of GR and AD value of different complexity game	81
4-5	The relations between GR and AD	85
4-6	The relations between reward frequency (N) and game length (D)	86
4-7	The relations between reward frequency (N) and AD	87
4-8	The crosspoint between fairness (y), reinforcement (v), entertainment (GR), and unpredictability (AD)	88
5-1	Game progression velocity as a function of risk rate m	94
5-2	Motion in Mind Measures for $k = 3$	96
5-3	Total and each round solved game uncertainty	99
5-4	Possible relation between performance degree and risk rate	101
5-5	The comparison of energy in mind based on the player performance level k	103
5-6	Motion in mind measure compared based on the performance degree k transition from 3 to 2	105
5-7	Comparison of momentum in mind based on the player performance level k	105
5-8	The comparison of subjective momentum in mind based on the player performance level k	106

5-9	Performance Level k and Reward Frequency N	108
5-10	The relations between k and AD	109
5-11	The relationship between N and AD in the sports domain	110
5-12	The relationship between N and AD in the board games domain	111
5-13	The relationship between N and AD in the card games domain	113
5-14	The relations between N , k and AD	113
5-15	Gamification, Game and Competition	122

List of Tables

2.1	Measures of game refinement for board games	14
3.1	Measures of game refinement for popular board games, adopted from [1]	32
3.2	Contextual correspondence between game information progress, Newton dynamics, and their link	35
3.3	Contextual link between physics, games, and psychology	36
3.4	Quintessential two-sided time-limited shooting game - basketball (adopted from [2] and basketball reference website*)	37
3.5	Measures of game refinement for soccer game according to [3]	39
3.6	Links between board game to soccer, where D is total shots, B is average feasible options, B_1 is average promising options (i.e., n is assumed as ideal options $n = \sqrt{B_1}$), GR is the informational acceleration, and AD is the informational jerk.	39
3.7	The Correspondence between Game Context and Non-Game Context using S (Scores)	44
3.8	Analogical translation between motion in minds, its game-playing implications, and its psycho-physiological context	47
3.9	Dynamical emotions and the corresponding description	51
4.1	Comparison of card games considered in this study	62
4.2	The card types of Wakeng	63
4.3	The card types of Doudizhu	64

4.4	Measures of game refinement for board games	69
4.5	The experiment design of Wakeng and Doudizhu	74
4.6	Measures of game refinement for classical DouDiZhu	75
4.7	Results of different levels of AI with different DouDiZhu game settings	75
4.8	The analysis of Wakeng based on different level AI based on the setting of (3, 1, 2)(20,16,16)	77
4.9	The analysis of several card games based on different level AI and setting	78
4.10	Closeness to reasonable zone of GR and AD given by different levels of players of different game complexity	80
4.11	The entertainment aspects of different GR and AD value expression . .	80
4.13	The comparison of suit-relevant card games based on a standard setting	82
4.12	The comparison of suit irrelevant based on a standard setting	82
4.14	Summary of motions in mind measures of different games	83
4.15	Possible corresponding games	89
4.16	Possible principle of game element	89
5.1	Relations between m and k	102
5.2	The relationship between N and AD in the sport games domain	110
5.3	The relationship between N and AD in the board games domain	111
5.4	The relationship between N and AD in the card games domain	112
5.5	Correlation between player performance and game characteristics . . .	114
5.6	Comparison between Perfect Information Games and Imperfect Informa- tion Games	116
5.7	Measures of game refinement for board games [4]	117
5.8	Comparison of Card Games using GR and AD values [5]	117
5.9	Comparison of Basketball and Soccer using GR and AD values [6] . . .	118
5.10	Comparison of Hotels using GR and AD values [7]	119
5.11	Comparison of Languages in Duolingo using GR and AD values [8] . .	120

5.12 Game types compared using ϕ values 121