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Information Dynamics in Boxing

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Abstract:
This paper is concerned with information dynamics in boxing. A world boxing title match of fly-class, Tanaka vs. Taguchi, held on March 16, 2019, at Gifu Japan has been analyzed. The defending champion, Tanaka keeps the advantage through the match, and thus the advantage increases with increasing the normalized game length (or time), except at 9th round. The certainty of game outcome increases gradually with increasing the normalized game length until the end of the match, and then it jumps from about 0.04 to the full value of 1 at the end. Thus, this match is classified as a balanced game. It is found that Tanaka gets the safety lead against Taguchi at about 93 % of the total game length. This result reflects very clearly how this match is tightly balanced until near the end. It is inferred that if full information on both players such as ranking and/or game records are provided, history and outcome of the boxing are predictable before the match starts in terms of the proposed method of analyses.

Keywords: Boxing, Game, Advantage, Certainty of Game Outcome, Game Point

INTRODUCTION

Everything can be viewed as a single game as far as it starts and ends eventually. Of course, life, annual ring of a tree, construction work, judo [1], baseball [2], effect of medicine [3], soccer [4] or shogi [6] are not the exception. It is, therefore, necessary to examine how each the event changes depending on the time during the game. Since 2010, the information dynamic model has been researched extensively and developed by Nakagawa et al [1, 2] in terms of the boundary layer theory in fluid mechanics. This model brings a kind of break-through in the game analyses, for it incorporates notion of the time in it for the first time. It becomes possible to discuss how advantage, and certainty of game outcome, change with time before, during and after the game: In principle, we could not only reflect the game after it is over, but predict the game before it starts, if necessary and time before, during and after the game: In principle, we could not only reflect the game after it is over, but predict the game before it starts, if necessary and sufficient information regarding to players (or teams) such as ranking and/or game records, is provided. Obvious candidates of natural phenomena or games, to be considered in future, are typhoon (cyclone), earthquake, flood, tsunami, climate, business fluctuations, horse racing, bicycle race, motor boat race, gambling, and many others.

As far as the author is aware of, all previous theories, possess no potential to analyze a game in such a way how it changes with game length (or time). For example, von Neumann's game theory [7] is concerned with only a few outcomes due to each the decision by players.

Nakagawa & Minatoya [1] has proposed a new notion coined 'game point', which is the cross point between certainty of game outcome and uncertainty of game outcome. That is, once game length (or time) exceeds to this point, one team gets the safety lead against the other.

Main purpose of the present study is to examine the WBO (World Boxing Organization) Fly-Class Title Match, Kosei Tanaka (defending champion) vs. Ryoichi Taguchi(challenger), held on March 16, 2019 at Gifu Memorial Centre, Japan by the analyses, in order to obtain new insights regarding to boxing or martial art.

METHOD OF ANALYSES

Elemental Procedure

For clarity, elemental procedure for obtaining the advantage α, certainty of game outcome ξ, and uncertainty of game outcome ς will be explained by using a soccer game between teams A and B, where only goal is assumed to be the evaluation function score, which may be defined as critical factor(s) for the game outcome.

The advantage α is defined as follows: When the total score(s) of the two teams at the end of game

$$S_T \neq 0,\ \alpha = [S_A(\eta) - S_B(\eta)]/S_T \text{ for } 0 \le \eta \le 1, \quad (1)$$

where $S_A(\eta)$ is the current score sum for team A(winner), and $S_B(\eta)$ is the current score sum for team B(loser). This means that when α>0, team A (winner) gets the advantage against team B (loser) in the game, while when α<0, team B(loser) gets the advantage against team A(winner). It is certain that when α=0 the game is balanced. Note that goal is merely one of the evaluation function scores in soccer, but in addition to goal, shoot, penalty kick, free kick or corner kick may be candidates of the evaluation function score. It is critical how assessor(s) chooses and assesses the evaluation function scores during the game. When the total score(s) of the two teams at the end of game $S_T = 0$, $\alpha = 0$ for $0 \le \eta \le 1$.

The certainty of game outcome ξ during the game is defined as follows: When the total score(s) of the two teams at the end of game $S_T \neq 0$, $\xi = |S_A(\eta) - S_B(\eta)|/S_T$ for $0 \le \eta < 1$

$$\xi = 1 \text{(normal game) or 0 (draw game) at } \eta = 1. \quad (2)$$

At η=1, ξ is assigned to the value of 1, for at the end of game the information on the game outcome must be 100%. The reason why we take the absolute value of the advantage α to get the certainty of game outcome ξ for $0 \le \eta < 1$ is that ξ is independent of the sign of α. This may be reasonable if one considers meaning of the certainty of game outcome: As far as the absolute value of the advantage α increases (or decreases), the certainty of game outcome ξ must increase (or decrease). In case of draw game, ξ may be assigned to the value of 0 at the end of game η=1. When the total score(s) of the two teams at the end of game $S_T = 0$, $\xi = 0$ for $0 \le \eta \le 1$

The uncertainty of game outcome ς during the game is defined as follows $\varsigma = 1 - \xi$. (3) This equation denotes that the current uncertainty of game outcome ς can be obtained by subtracting the current certainty of game outcome ξ from value of 1. The game length is the current length (or time) from the start of the game, and is normalized by the total game length (or total time) to obtain the normalized game length η.

DATA ANALYSES

Keeping in mind the forgoing elemental procedure to obtain the advantage α, certainty of game outcome ξ, and uncertainty of game outcome ς, it may be straight forward to apply them to actual boxing games. In boxing, point(s) assessed by each the referee must be evaluation function score(s), for it is most reliable and critical information regarding to the match outcome. In computer chess, evaluation function score(s) for each of the moves has been successfully assessed by a computer based on objective human evaluation function scores that are adopted for the data analyses of human and computer interaction in shogi between Kunio Yonenaga (Shogi Meijin) and Bonkras (Computer Shogi World Champion in 2012) [6].

In this study, WBO (World Boxing Organization) Fly-Class Title Match, Kosei Tanaka (defending champion) vs. Ryoichi Taguchi (challenger) has been analyzed.

Table 1 summarizes results of data analyses for the match based on points assessed by Rasend (USA) together with points assessed by Steidel (Puerto Rico) and Harada (Japan). The total game length is 12 rounds, and the total evaluation scores are 228, where each of the points assessed by the main referee, Rasend is only counted as evaluation function score in the present analyses, as the representative of three referees.

In this match, after the start, Tanaka (age 23, weight 50.8 kg, Hatanaka club) gets the advantage for all of the rounds except 9th round, where Taguchi (age 32, weight 50.8 kg, Watanabe club) attacks to Tanaka, so Tanaka keeps and increases the advantage α with increasing the normalized game length η as shown in Table 1. Note that in the third round, Taguchi's right short straight hits to Tanaka and thus referee, Harada assesses that punch, but this is not assessed by the referees, Rasend, and Steidel.

Table 1 shows that three referees have judged in such a way that Tanaka is the winner, while Taguchi is the loser in this match unanimously.

Table 1: Game records of WBO Fly-Class Title Match: Tanaka vs. Taguchi

η	α
0	0
0.0769	0.00439
0.1538	0.00877
0.2308	0.0132
0.3077	0.0175
0.3846	0.0219
0.4615	0.0263
0.5385	0.0307
0.6154	0.0351
0.6923	0.0307
0.7692	0.0351
0.8462	0.0395
0.9231	0.0439
1	0.0439

Rasend(USA)		Steidel(Puerto Rico)		Harada(Japan)	
Tanaka	Taguchi	Tanaka	Taguchi	Tanaka	Taguchi
10	9	9	10	10	9
10	9	10	9	9	10
10	9	10	9	9	10
10	9	10	9	10	9
10	9	10	9	10	9
10	9	10	9	10	9
10	9	10	9	10	9
10	9	10	9	10	9
9	10	9	10	9	10
10	9	10	9	10	9
10	9	9	10	10	9
10	9	10	9	10	9

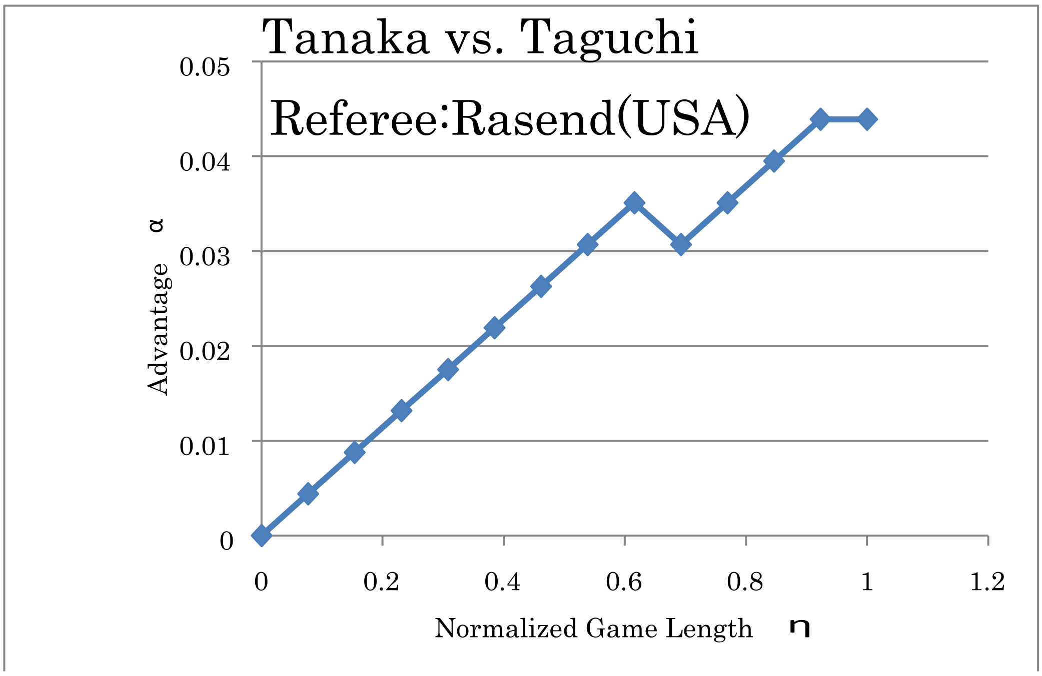

Figure 1: Advantage α against normalized game length η

Figure 1 shows the relation between advantage α and normalized game length η in the match, Tanaka vs. Taguchi. This figure indicates that Tanaka keeps the advantage through the match, and the advantage α increases with increasing the normalized game length η, except at 9th round.

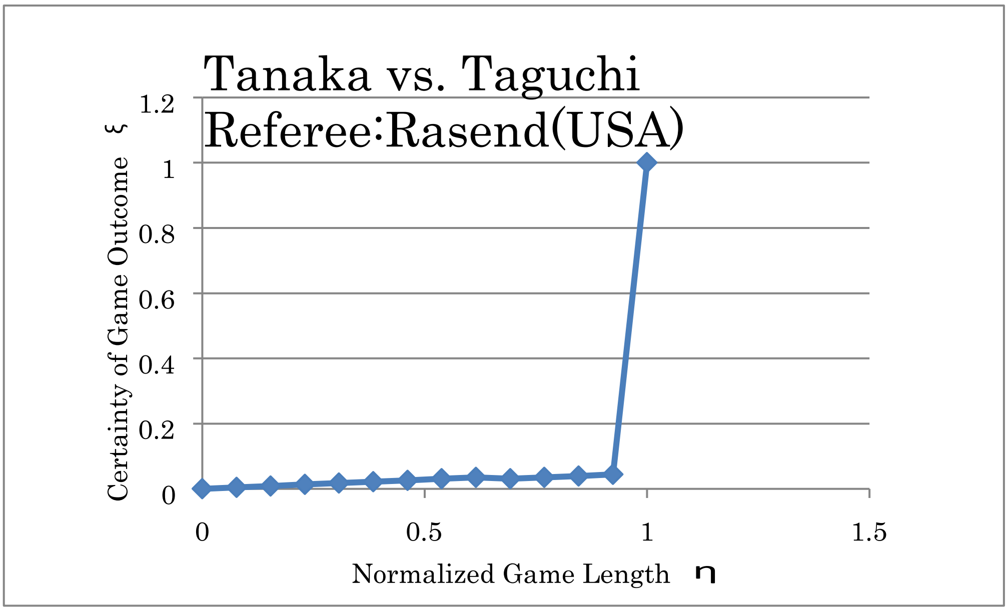

Figure 2: Certainty of game outcome against ξ normalized game length η

Figure 2 shows the relation between the certainty of game outcome ξ and the normalized game length η in the match, Tanaka vs. Taguchi. This figure indicates that the certainty of game outcome ξ increases gradually with increasing the normalized game length η until the end of the match, and then it jumps from about 0.04 to the full value of 1 at the end. That is, balanced from the start to the end is this match, which is called balanced game [5]. Boxing is essentially sudden death game, for once one player knocks out the opponent player, it will be over: The former becomes the winner, while the latter becomes the loser being independent of the previous points, which are only valuable when the match continues to the final 12th round.

DISCUSSION

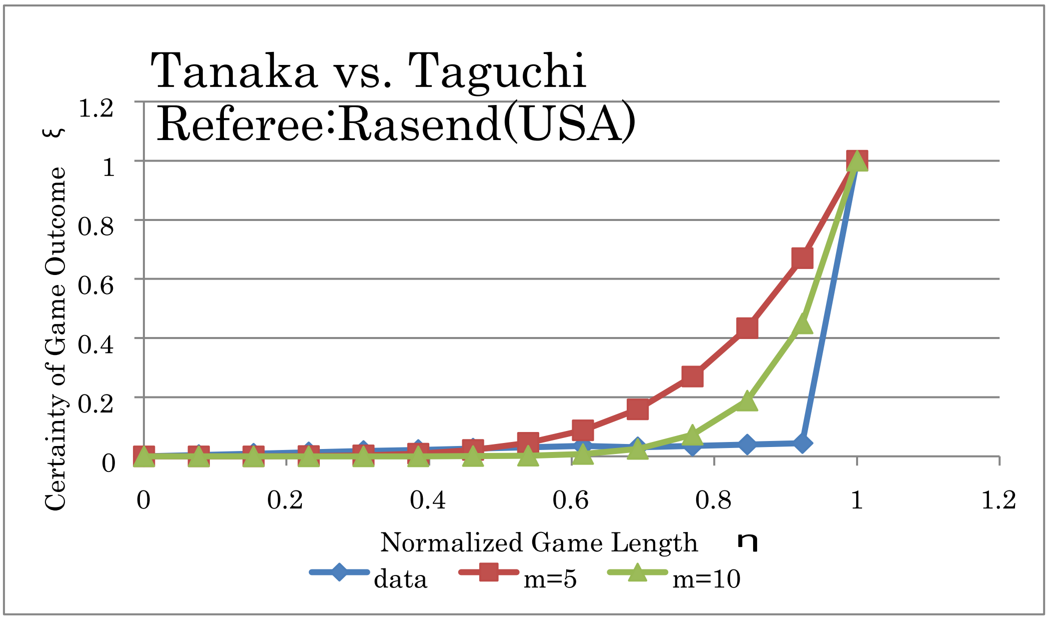

Figure 3: Certainty of game outcome ξ against normalized game length η

The match, Tanaka vs. Taguchi will be discussed with reference to information dynamic model, which is expressed by

$$\xi = \eta^{m}, \tag{4}$$

where ξ is certainty of game outcome, η is normalized game length, and m is a positive real number. For full account of the information dynamic model, refer to Appendix. Figure 3 shows the relation between certainty of game outcome ξ and normalized game length η, where game data of Tanaka vs. Taguchi together with two curves of the information dynamic model $\xi= \eta^5$ and $\xi= \eta^{10}$ respectively, have been plotted concurrently.

It may be considered that curve $\xi = \eta^{10}$ fits the data fairly well, so that using this curve the game point, which is the cross point between the certainty of game outcome $\xi=\eta^{10}$ and the uncertainty of game outcome $\varsigma = 1 - \eta^{10}$ will be determined.

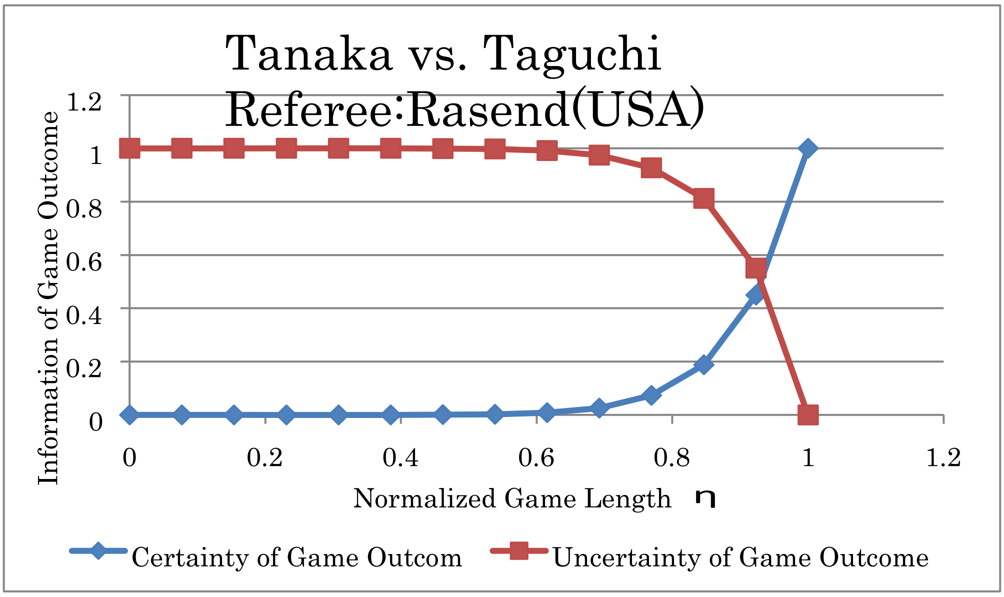

Figure 4: Information of game outcome against normalized game length η

Figure 4 shows relation between the information of game outcome and normalized game length η, where certainty of game outcome $\xi=\eta^{10}$ and uncertainty of game outcome $\varsigma = 1 - \eta^{10}$ have been plotted concurrently. It is found that the game point is $\eta_G \approx 0.93$. This means that Tanaka gets the safety lead at about 93 % of the total game length. This result reflects very clearly how this match is tightly balanced until near the end.

As far as we examine the history of advantage α, this match looks as if a typical one-sided game, but this match is balanced one actually.

It may be worth pointing out that the information dynamic model possesses a potential to predict game outcome, where information of game outcome is expressed as depending on the game length (or time). Using initial conditions such as player' s ranking, and/or game record, value of the parameter 'm' in the model expression (4), or (14) may be obtained before a game starts. It is clear that once this value is known, the history and outcome of the game can be predicted, for it will proceed along one of the model curves as plotted in Figure 6 from start to end. The information dynamic model is applicable to predict future trends in GDP (Gross

Domestic Product), population, or temperature, where current information such as an inclination angle of the relevant curves is critical.

CONCLUSION

In this section, new knowledge and insights obtained through the present study are summarized.

1. The defending champion, Tanaka keeps the advantage against Taguchi through the match, and thus the advantage increases with increasing the normalized game length (or time), except at 9th round.
2. The certainty of game outcome increases gradually with increasing the normalized game length until the very end of the match, and then it jumps to the full value of 1 in the end. That is, this match is so called balanced game.
3. It is found that the game point is at about 0.93 of the normalized game lengths, so that Tanaka gets the safety lead against Taguchi at about 93 % of the total game length. This result reflects very clearly how this match is tightly balanced until near the end.
4. It is inferred that if a full of information on both players such as ranking and/or game records are provided, history and outcome of the boxing are predictable before the match starts in terms of the proposed method of analyses.

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Appendix: Information Dynamic Model

Currently, information dynamic model only makes it possible to treat and identify game progress patterns depending the game length (or time). In this model, information of game outcome is expressed as a simple analytical function depending on the game length, where information of game outcome is certainty of game outcome. In this Appendix, the information dynamic model has been introduced.

Modelling Procedure

The modeling procedure of information dynamics based on fluid mechanics is summarized as follows:

a) Assume a flow as the information dynamic model and solve it.
b) Get the solutions, depending on the position (or time).
c) Examine whether any solution of the flow can correspond to game information.
d) If so, visualize the assumed flow with some means. If not, return the first step.
e) Determine the correspondence between the flow solution and game information.
f) Obtain the analytical expression of the information dynamic model.

The information dynamic model will be constructed by following the above procedure step by step.

a) Let us assume flow past a flat plate at incident angle of zero as the information dynamic model (Figure 5). Note that this velocity profile is merely one typical example, but it is known there are many other velocity profiles depending on boundary and initial conditions.

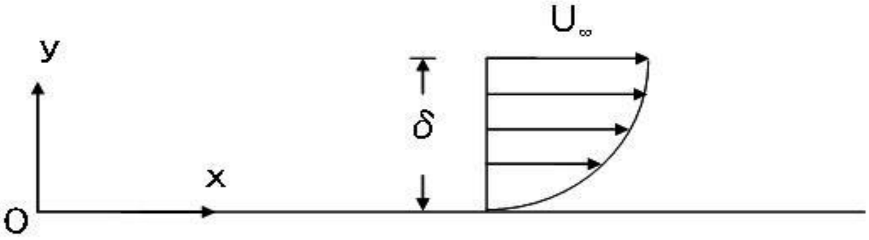

Figure 5: Definition sketch of flow past a flat plate at incident angle of zero.

An example of the application of the boundary-layer equations, which are the simplified version of Navier-Stokes equations [10], is afforded by the flow along a very thin flat plate at incident angle of zero. Historically this is the first example illustrating the application of Prandtl's boundary layer theory [9]; it has been discussed by Blasius [8] in his doctoral thesis at Göttingen. Let the leading edge of the plate be at x=0, the plate being parallel to the x-axis and infinitely long downstream, as depicted in Figure 5. We shall consider steady flow with a free-stream velocity U, which is parallel to the x-axis. The boundarylayer equations [9,10] are expressed by

$$u \cdot \partial u/\partial x + v \cdot \partial u/\partial y = -1/\rho \cdot dp/dx + \nu \partial^2 u/\partial y^2, \quad (5)$$

$$\partial u/\partial x + \partial v/\partial y = 0 \quad (6)$$

$$y = 0: u = v = 0; \; y = 1: u = U \quad (7)$$

where u and v are velocity components in the x- and y- directions, respectively, ρ the density, p the pressure and ν the kinematic viscosity of the fluid. In the free stream,

$$U \cdot dU/dx = -1/\rho \cdot dp/dx. \tag{8}$$

The free-stream velocity U is constant in this case, so that dp/dx=0, and obviously dp/dy =0. Since the system under consideration has no preferred length, it is reasonable to suppose that the velocity profiles at varying distances from the leading edge are similar to each other, which means that the velocity curves u(y) for varying distances x can be made identical by selecting suitable scale factors for u and y. The scale factors for u and y appear quite naturally as the free-stream velocity, U and the boundary-layer thickness, δ(x), respectively. Hence, the velocity profiles in the boundary-layer can be written as

$$u/U = f(y/\delta). \tag{9}$$

Blasius [8] has obtained the solution in the form of a series expansion around y/δ= 0 and an asymptotic expansion for y/δ being very large, and then the two forms are matched at a suitable value of y/δ.

b) The similarity of velocity profile is here accounted by assuming that function f depends on y/δ only, and contains no additional free parameter for each of the profile. The function f must vanish at the wall (y = 0) and tend to the value of 1 at the outer edge of the boundary-layer (y = δ).

   When using the approximate method, it is expedient to place the point at a finite distance from the wall, or in other words, to assume a finite boundary-layer thickness δ(x), in spite of the fact that all exact solutions of boundary-layer equations tend asymptotically to the free-stream associated with the particular problem.

   The ‘approximate method’ here means that all the procedures are to find approximate solutions to the exact solutions respectively. When writing down an approximate solution of the present flow, it is necessary to satisfy certain boundary condition for u(y). At least the no-slip condition u = 0 at y = 0 and the condition of the continuity when passing from the boundary-layer profile to the free-stream velocity, so that u = U at y =δ, must be satisfied.

   It is evident that the following velocity profiles satisfy all of the boundary conditions for the assumed flow past a flat plate at incident angle of zero,

$$u/U = (y/\delta)^{m}, \tag{10}$$

   where m is positive real number. Eq. (10) is heuristically derived, and represents a group of the approximate solutions for the assumed flow, taking each the different value of m. In case of m=1, (10) reduces to an exact solution for the boundary-layer equations, and the rest solutions are considered as the approximate solutions to the other exact solutions, respectively.

c) Let us examine whether these solutions are game information or not. Such an examination immediately provides us that the non-dimensional velocity varies from 0 to 1 with increasing the non-dimensional vertical distance y/δ in many ways as the non-dimensional information varies from 0 to 1 with increasing the normalized game length, so that these solutions can be game information. However, validity of this conjecture will be confirmed by the relevant data.

d) Imagine that the assumed flow is visualized with neutral buoyant particles. Motion of the visualized particles is detected by the eye almost instantaneously through the lights and is mapped on our retina first [11], so that during these processes, motion of 'fluid particles' is transformed into that of the 'information particles' by the light carrying the images of fluid particles. This is why motion of the fluid particles is intact in the physical space, but only the reflected lights, or electromagnetic waves consisting of photons can reach at the retina. The photons are then converted to electrochemical particles and are passed along the visual cortex for further processing in parts of the cerebral cortex [11]. The photons and/or electrochemical particles are considered to be information particles. It is, therefore, natural to expect that the flow in the physical space is faithfully transformed to that in the information space, or brain including eye. During this transformation, the flow solution in the physical space changes into the information solution in the information space.

e) Proposed are correspondences between the flow and game information, which are listed in Table 2.

Table 2: Correspondences between the flow and game information

Flow	Game
u: flow velocity	I:current information
U: free stream velocity	I_0: total information
y: vertical co-ordinate	t: current game length
δ: boundary layer thickness	t_0: total game length

f) Considering the correspondences in Table 2, (10) can be rewritten as

$$I/I_o = (t/t_o)^{m} \tag{11}$$

Introducing the following normalized variables in (11),

$$\xi = I/I_o \text{ and } \eta = t/t_o, \tag{12}$$

we finally obtain the analytical expression of the information dynamic model as

$$\xi = \eta^m \tag{13}$$

where ξ is the normalized information, η the normalized game length, and m is a positive real number. Figure 6 shows the relation between certainty of game outcome ξ and normalized game length η (or time), where a total of 10 model curves have been plotted concurrently. This figure clearly suggests versatility of this model (13), for each of the curve is considered to represents a game. Thus, this model can represent any game in principle, for the parameter 'm' in (13) can take any positive real number. The smaller the strength difference between both players (or teams) is, the greater the value of m, and *vice versa*. This means that each the game takes a unique value of m, and thus experiences its own history with increasing the game length (or time).

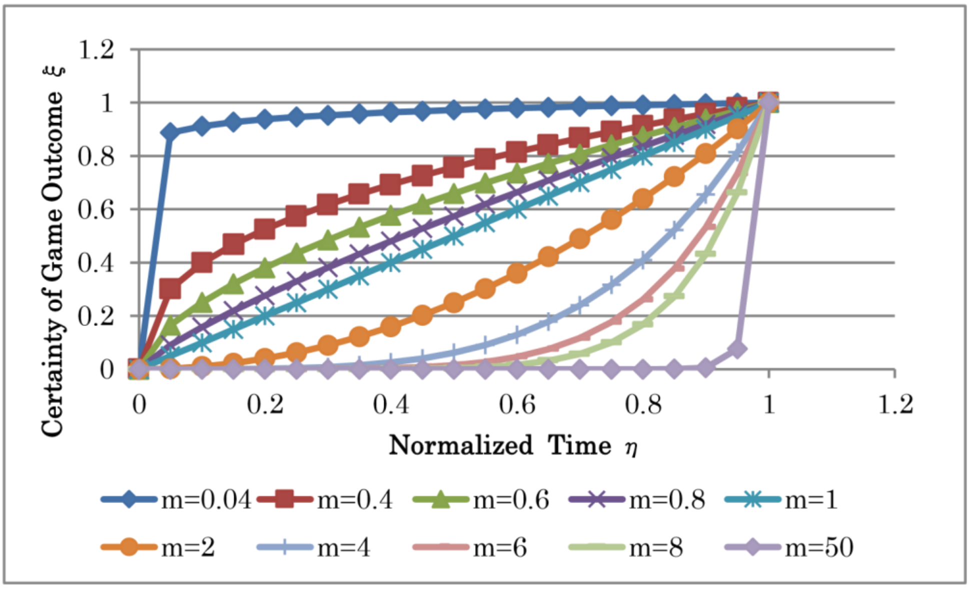

Figure 6: Certainty of game outcome ξ against normalized game length η.