Three Elemental Game Progress Patterns

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Abstract. This paper is concerned with three elemental game progress patterns. It is found that each of the three games in 2010 FIFA World Cup, Group E is a combination of the elemental progress patterns. It is confirmed that the analysed Soccer and Chess games are a combination of the elemental game progress patterns. It is suggested that this finding is universal for all games. Time history of information of game outcome obtained by data analyses and existing models suggests that for neutral observers a "balanced game" is frustrating, a "one-sided game" is boring, and a "seesaw game" is exciting.

Keywords: Game Progress Patterns, Game Model, Soccer, Chess, Entertainment

1 Introduction

While knowledge about game design patterns and game play patterns has grown fairly well, little advancement has been made to clarify game progress patterns, which show how information of game outcome depends on game length or time. Making use of game design patterns, Kelle et al(2010) have implemented information channels to simulate ubiquitous learning support in an authentic situation. Lindley & Sennersten(2008)'s schema theory provides a foundation for the analysis of game play patterns created by players during their interaction with a game. Lindley & Sennersten(2006) have proposed a framework which is developed not only to explain the structures of game play, but also to provide schema models that may inform design processes and provide detailed criteria for the design patterns of game features for entertainment, pedagogical and therapeutic purposes.

Salen & Zimmerman(2003) and Fullerton et al(2006) argue in favor of an iterative design method, which relies on inviting feedback from players early on. ' Iterative ' refers to a process in which the game is designed, tested, evaluated and redesigned throughout the project. As part of this approach designers are encouraged to construct a first playable version of the game immediately after brainstorming and this way get immediate feed back on their ideas (Fullerton et al 2006). Play-testing, which lies at the heart of the iterative approach, is probably the most established method to involve players in design. Play-testing is not primarily about identifying the target audience or tweaking the interface, but it is performed to make sure that the game is balanced, fun to play, and functioning as intended(Fullerton et al 2006).

The Game Ontology Project (Zagal et al 2005) offers a framework for describing, analyzing, and studying games by defining a hierarchy of concepts abstracted from an analysis of many specific games. The project borrows concepts and methods from prototype theory and grounded theory to achieve a framework that is continually evolving with each new game analysis or particular research question. The term ontology is introduced from computer science rather than used in the philosophical sense. It refers to the identification and description of entities within a domain. This project is distinct from design rules and design patterns approaches that offer imperative advice to designers. It intends not to describe rules for creating good games but rather to identify the abstract commonalities and difference in design elements across a wide range of concrete examples. The ontological approach is also distinct from genre analyses and related attempts to answer the question "What is a game?". Rather than develop definitions to distinguish between games and non-games or among their different types, it focuses on analyzing design elements that cut across a wide range of games. Its goal is not to classify games according to their characteristics and mechanics(Lundgren & Björk 2003) but to describe the design space of games. Another project seeking the same goals using a different methodological approach can be seen in Björk & Holopainen(2005).

Game information dynamic models(Iida et al 2011a, 2011b) make it possible to treat and identify game progress patterns and thus enhance their detailed discussion. In these models, information of game outcome is expressed as the analytical function of the game length or time, where information of game outcome is the data that is the certainty of game outcome. The two models are expressed, respectively, by

$$\text{Model } 1 : \xi = \eta^n,$$

and

$$\text{Model } 2 : \xi = \left[sin\left(\frac{\pi\eta}{2}\right)\right]^n,$$

where ξ is the non-dimensional information, η the non-dimensional game length or time, and n the positive real number parameter. The value of the parameter n depends on the game factors, strength of the two teams (players), and strength difference between the two teams (players).

It is realized that there are various game progress patterns in Base Ball(Iida et al 2011a, 2011b) , Soccer, Chess, Shogi and many others. In general, each game proceeds with time in its characteristic manner. None the less, we often encounter similar game progress patterns in each game, so that it is quite useful in attempting to understand the nature of game if we can identify and extract elemental game progress patterns, which are common in many games.

The main purpose of the present study is to confirm that games consist of the three elemental game patterns based on actual Soccer games, a Chess game and existing game models, and clarify how emotion of neutral observer(s) varies with the elemental game progress patterns.

2 Elemental Game Progress Patterns

Three elemental game progress patterns, called “balanced game”, “seesaw game” and “one-sided game” have been heuristically found by the present authors during the investigation of information dynamics on Base Ball(Iida et al 2011a, 2011b), Soccer and many others, such as Shogi, Go, Chess, Tic-Tac-Toe, Congkok, or Othello. It is realized that each real game is a combination of the three elemental game progress patterns, though there are several supplementary game progress patterns such as “catchup game” and “against all odds game”. In a “catchup game”, one team(player) always breaks a tie in their favor, but it goes back to tied again, while in “against all odds game”, one team(player) has a significant lead, but towards the end of the game, the other team(player) recovers and wins. The elemental game progress patterns have been introduced here by using three artificial Soccer games as listed in Table 1. Examples of the three artificial Soccer games have been proposed so as to satisfy ideal conditions, to be defined for each game.

The way to calculate the advantage depends on game type, so in this study, Soccer and Chess have been examined as a field game fighting with one another for goals, and a board game where players compete with one another for evaluation function score(David-Tabibi et al 2008).

Table 1 Time history of goals for three artificial Soccer games between team A and team B

Game	Result (A – B)	Goal time (Scoring team)
balanced game	0 - 0	
seesaw game	5 - 4	10(A), 20(B), 30(B), 40(A), 50(A), 60(B), 70(B), 80(A), 90(A)
one-sided game	9 - 0	10(A), 20(A), 30(A), 40(A), 50(A), 60(A), 70(A), 80(A), 90(A)

The non-dimensional information ξ_s in Soccer is here defined as follows: When the total goal(s) of the two teams at the end of the game $\mathrm{G_T} \neq 0$,

$$\xi_S = \begin{cases} \frac{|\mathrm{G_A}(\eta)-\mathrm{G_B}(\eta)|}{\mathrm{G_T}} & for \;\; 0 \leq \eta < 1 \\ 1 & for \;\; \eta = 1, \end{cases}$$

where $\mathrm{G_A}\,(\eta)$ is the current goal sum for the team A(winner), and $\mathrm{G_B}\,(\eta)$ is the current goal sum for the team B(loser). At $\eta = 1$, ξ_S is assigned the value of 1, for at the end of a game the information must reach the total information of game outcome. On the other hand, when $\mathrm{G_T} = 0$,

$$\xi_S = \begin{cases} 0 & for \;\; 0 \leq \eta < 1 \\ 1 & for \;\; \eta = 1. \end{cases}$$

Note that in a draw case ξ_S may also take the value of 0 other than 1 at $\eta = 1$, depending on the game rules. In the case of a tournament match, $\xi_S = 1$ at $\eta = 1$, while in the case of a league match, $\xi_S = 0$ at $\eta = 1$.

The game length is defined as the current time (minutes), and it is normalized by the total time or the total game length to obtain the non-dimensional value η. The total game length of Soccer is normally 90 minutes, but in case of extended games it becomes 120 minutes. It is convenient to discuss game progress patterns by using non-dimensional certainty of game outcome against non-dimensional game length, because one could know current certainty of game outcome in the range between 0 and 1 at any game length in the same range.

Balanced game: Both of the teams have no goal through the game.

Seesaw game: One team leads, then the other team leads, and this may be repeatedly alternate. It is, however, necessary that the current goal difference between the two teams must be smaller than the current safety lead, which is such that once the goal difference exceeds its value, the leading team will win the game with 100% certainty. Note that the safety lead decreases with increasing the game length and depends on the game factors, including the strength of the two teams and strength difference between the two teams. This suggests the existence of the safety lead curve such that once the game advantage goes above it, the advantageous team will win the game with 100% certainty.

One-sided game: The current goal sum of one team(winner) is always greater than that of the other team(loser), so that the goal difference between the two teams is always positive. However, a “one-sided game” is further divided into “complete one-sided game or state” and “incomplete one-sided game or state”. When the goal difference is smaller than the current safety lead, it is called “incomplete one-sided game or state”. On the other hand, when the goal difference is greater than the current safety lead, it is called “complete one-sided game or state”. However, when a game changes from incomplete one-sided state to complete one-sided state and finishes, it is simply called “one-sided game”. Figure 1 shows the relation between the non-dimensional information ξ_S and non-dimensional game length η for the artificial one-sided game. In this figure, the curve of Model 1 at $n = 1$ is plotted for reference and accounts for a one-sided game.

The non-dimensional advantage α_S is here defined as follows: When the total goal(s) of the two teams at the end of the game $\mathrm{G_T} \neq 0$,

$$\alpha_S = \frac{|\mathrm{G_A}(\eta) - \mathrm{G_B}(\eta)|}{\mathrm{G_T}} \quad for \;\; 0 \leq \eta \leq 1.$$

On the other hand, when $\mathrm{G_T} = 0$,

$$\alpha_S = 0 \;\; for \;\; 0 \leq \eta \leq 1.$$

This means that when $\alpha > 0$, team A(winner) gets the advantage against team B(loser) in the game, while when $\alpha < 0$, team B (loser) gets the advantage against team A(winner). When $\alpha = 0$ the game is balanced.

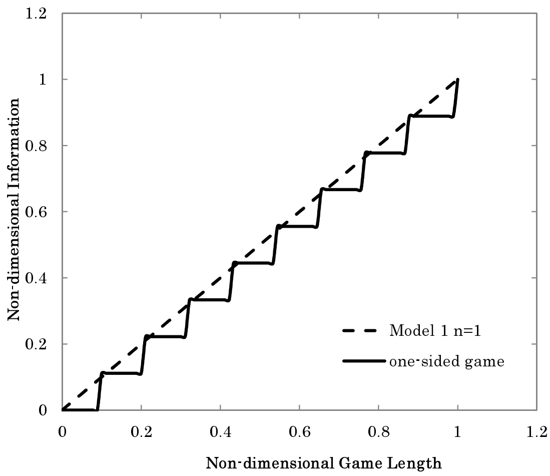

Fig. 1. Non-dimensional information ξ_S against non-dimensional game length η for the artificial one-sided game.

3 Three Soccer Games in 2010 FIFA World Cup

In this section, some results of the data analyses on the three Soccer games in 2010 FIFA World Cup, Group E will be presented. Then the game progress patterns will be discussed with reference to information dynamic models, Model 1 and Model 2. Some of the relevant information on the three Soccer games in 2010 FIFA World Cup are summarized in Table 2.

Table 2 Three Soccer games in 2010 FIFA World Cup, Group E

Game Result	Goal time (min.)	Total game length(min.)	Date	Place
Holland 2-0 Denmark	45(Holland) 85(Holland)	90	June 14	Yohannesburg
Denmark 2-1 Cameroon	10(Cameroon) 33(Denmark) 61(Denmark)	90	June 19	Pretoria
Holland 2-1 Cameroon	36(Holland) 65(Cameroon) 85(Holland)	90	June 24	Cape Town

Figure 2 shows the relation between the non-dimensional information ξ_S and non-dimensional game length η for three Soccer games in 2010 FIFA World Cup, Group E. Denmark vs. Cameroon and Holland vs. Cameroon have a common character that the information increases rapidly near the end. These games are accounted for by Model 1. This has been also suggested by Iida et al(2004). On the other hand, Holland vs. Denmark has a distinctive feature that the

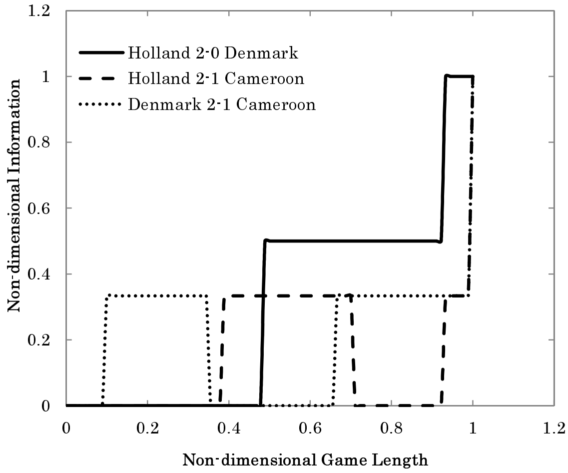

Fig. 2. Non-dimensional information ξ_S against non-dimensional game length η for three Soccer games.

information gradually approaches to the total value of game outcome. This game can be accounted for by Model 2.

Figure 3 depicts the relation between non-dimensional advantage α and non-dimensional game length η for the three Soccer games in 2010 FIFA World Cup, Group E. This figure, therefore, illustrates how the non-dimensional advantage α of each game changes with the non-dimensional game length η. In the case of Holland vs. Denmark, it is balanced until $\eta \simeq 0.49$, but then the advantage α increases and takes the value of 0.5 at $\eta \simeq 0.49$ and then becomes the value of 1 at $\eta \simeq 0.93$, keeping this value until $\eta = 1$. In the case of Denmark vs. Cameroon, it is balanced until $\eta \simeq 0.10$, but Cameroon gets the first goal and thus keeps the advantage from $\eta \simeq 0.10$ to 0.36. However, the game becomes the second balanced state from $\eta \simeq 0.36$ due to Denmark's goal and this is kept until $\eta \simeq 0.67$, but Denmark gets her second goal at $\eta \simeq 0.67$ and keeps her advantage and the game finishes at $\eta = 1$. In the case of Holland vs. Cameroon, it is balanced until $\eta \simeq 0.39$, but the balance breaks at $\eta \simeq 0.39$ due to Holland's first goal and then Holland keeps the advantage until $\eta \simeq 0.71$. However, due to Cameroon's goal at $\eta \simeq 0.71$, the game becomes its second balanced state and this continues until $\eta \simeq 0.93$ at which point Holland gets her second goal, and maintains the advantage until the end.

Figures 2 and 3 show that in Holland vs. Denmark, the game changes smoothly from "incomplete one-sided state" to "complete one-sided state" with increasing η and finishes, (though it is balanced from $\eta = 0$ to 0.49). Thus, we may state that this game is a combination of "one-sided game" and "balanced game". Denmark vs. Cameroon is a "seesaw game", (though it is balanced during two interval, from $\eta = 0$ to $\simeq 0.10$ and from $\eta \simeq 0.36$ to $\simeq 0.67$). Thus, we may state that this game is a combination of "seesaw game" and "balanced game".

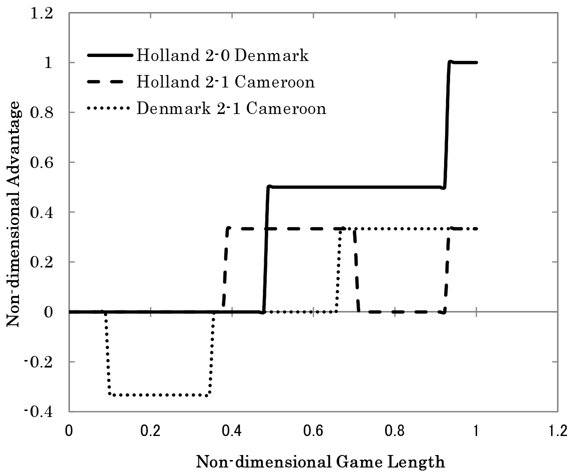

Fig. 3. Non-dimensional advantage α against non-dimensional game length η for the three Soccer games.

Holland vs. Cameroon is balanced during two intervals, from $\eta \simeq 0$ to $\simeq 0.39$ and from $\eta \simeq 0.71$ to $\simeq 0.93$. However, the goal difference between Holland(winner) and Cameroon(loser) during two intervals, viz. from $\eta \simeq 0.39$ to $\simeq 0.71$ and from $\eta \simeq 0.93$ to 1, is kept to be positive, but is only one. Thus, this game is considered as a combination of "incomplete one-sided game" and "balanced game".

4 Chess Data Analyses

In this section, it is inquired whether Chess can be expressed by a combination of the three elemental game progress patterns.

A Chess match was played between, GreKo6.5(White) and Booot4.15.1(Black), both of which are computer Chess Engines. In this game, Black mates White at the 25th move. Chess evaluators principle mechanism is to count and sum up the relevant materials(David-Tabibi et al 2008). A total of 25 evaluation function scores are collected from the computer Chess engine, GreKo6.5. one for each of White 's moves in that game. When the computer Chess engines determine the outcome of the game, they may provide an extremely high value of evaluation function score. In such a case, as the evaluation function score at the move, the maximum value within all of the previous moves is substituted for it. This modified evaluation function score is used as current advantage in our analysis. When the first engine(White) takes an advantage over the second engine(Black), the sign of the current advantage is positive, while in the reverse case it is negative. When both engines are even the current advantage becomes zero.

The non-dimensional information ξ_C in Chess is defined as follows:

$$\xi_c = \begin{cases} \frac{|\mathrm{Ad}(\eta)|}{\mathrm{ACT}(1)} & for\ \ 0 \leq \eta < 1 \\ 1 & for\ \ \eta = 1, \end{cases}$$

where $\mathrm{Ad}(\eta)$ is the current advantage as described above. ACT(1) is the total advantage change at the end of the match, such that

$$\mathrm{ACT}\left(\eta\right) = \mathrm{ACT}\left(\mathrm{m/N}\right) = \sum_{1 \leq i \leq \mathrm{m}} \left|\mathrm{Ad}\left(\mathrm{i}\right) - \mathrm{Ad}\left(\mathrm{i}-1\right)\right|,$$

Where m is the current move count, N the total move count, and i a positive integer. η is the non-dimensional game length, in which the current move count m is normalized by the total move count N.

The non-dimensional advantage α_C in Chess is defined as follows

$$\alpha_C = \frac{\mathrm{Ad}\left(\eta\right)}{\mathrm{ACT}\left(1\right)}\ \ for\ \ 0 \leq \eta \leq 1,$$

Figure 4 shows the relation between the non-dimensional information ξ_C and the non-dimensional game length η for the described Chess match. Figure 5 shows the relation between the non-dimensional advantage α_C and the non-dimensional game length η for the same match. Figures 4 and 5 indicate that from $\eta = 0$ to $\simeq 0.547$, the match is "balanced", from $\eta \simeq 0.547$ to $\simeq 0.767$, it is "seesaw", and from $\eta \simeq 0.779$ to $= 1$, it is "one-sided". Hence, it is considered that the present Chess match is a combination of "balanced", "seesaw" and "one-sided" states.

Regarding entertainment, in this Chess match the neutral observer(s) feel three different emotions, "frustrated", "excited" and "bored" during the balanced state, seesaw state and one-sided state, respectively, as to be discussed in the next section.

It is considered that the present results of the Chess match are supporting evidence to the statement that each game is a combination of the three elemental game progress patterns. It may be evident that this statement is applicable to many other games, such as Base Ball, Go, Shogi, or Basket Ball.

5 Entertainment

This section discusses the entertainment in games through a comparison between Model 1 (or Model 2) and the data on three Soccer games in 2010 FIFA World Cup, Group E. Before the discussion, it must be noted that winner(s), loser(s) and neutral observer(s) have different emotion during the game from each other, where winner(s) is winning player(s) and winner-sided observer(s) and loser (s) is losing player(s) and loser-sided observer(s). The present discussion on entertainment in games only inquires how neutral observer(s) feel emotion during the game as the first step to understand it. For neutral observer(s), "balanced game" is frustrating, for both of the teams have no goal through the game even

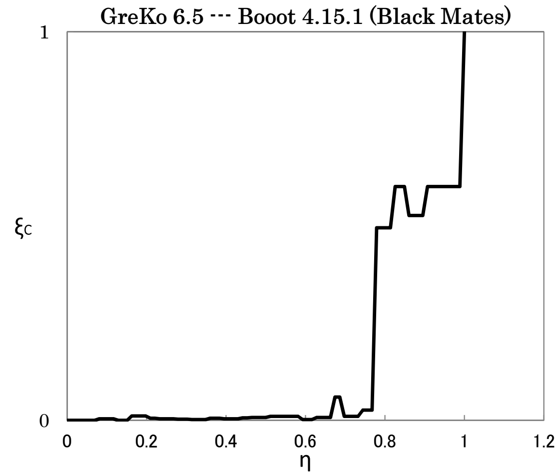

Fig. 4. Non-dimensional information ξ_C against non-dimensional game length η for Chess.

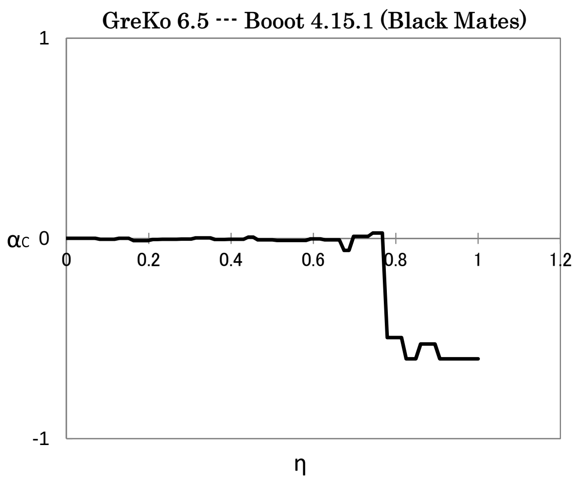

Fig. 5. Non-dimensional information α_C against non-dimensional game length η for Chess.

though the game may proceed experiencing alternate changes from offense to defense by the two teams many times. "One-sided game" is boring, for only one team scores goal(s) and the winning goal appears too early, and "seesaw game" is exciting, for both of the teams score goal(s) and advantage changes its sign during the game. However, it is important to note that how one feels emotions during a game is essentially private. The present discussion is therefore based on the author's subjective views of this problem, and a more general discussion is beyond the scope of the present study.

6 Conclusion

The new knowledge and insights obtained through the present investigation are summarised as follows.

Three elemental game progress patterns have been heuristically identified by observing real games, e.g. Base Ball, Soccer, Chess, Go and Shogi, and have been defined. It is found that each of the real games is essentially a combination of the three elemental game progress patterns, called "balanced game", "seesaw game" or "one-sided game", though there are several supplementary game progress patterns such as "catchup game" and "against all odds game". This has been confirmed by the three Soccer games in 2010 FIFA World Cup, Group E. Holland vs. Denmark is a combination of "one-sided game" and "balanced game", Denmark vs. Cameroon is a combination of "seesaw game" and "balanced game" and Holland vs. Cameroon is a combination of "incomplete one-sided game" and "balanced game". It is suggested that this finding is universal, and thus it is applicable to Base Ball, Chess, Go, Shogi, Boxing, Rugby, Hand Ball, Basket Ball and many others.

Time history of information of game outcome, which is obtained by the data analyses for the three artificial Soccer games, as well as the three Soccer games in 2010 FIFA World Cup, Group E, suggests that for neutral observers "balanced game" is frustrating, "one-sided game" is boring, and "seesaw game" is exciting. This insight is quite useful for game design, for one can design games in such a way that they become a "seesaw game", for example.

The information dynamic model $\xi = \eta^n$, where ξ is the non-dimensional information, η the non-dimensional game length, and n the real number positive parameter, has been used to assess the degree of excitement of games. In this model the "balanced game" takes the maximum value of n, the "one-sided game" takes the minimum value of n. The "seesaw game" takes the intermediate value of n. A comparison between the information obtained by the information dynamic model and that of the real game provides the degree of excitement in the game. The greater the value of n is, the more the game is exciting for neutral observer(s), and vice versa. In other words, the later the winning goal is, the more the game is exciting for neutral observer(s), and vice versa.

This work has clearly illustrated how to analyse games in terms of scoring outcomes(section 3) and in terms of evaluation function scores(section 4) or winning rate. The former examples are Soccer, Base Ball, Rugby, Hockey, Basketball, Volleyball, Boxing, Judo, Kendo, Karate and so forth, while the examples are Chess, Go, Shogi, Othello, Tic-Tac-Toe, Hex and many others.

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