

Sporting Graphs: The Play between Knowledge and Graphs

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The ontological study of Sports and our approach of using graphical representations to analyse, classify and attempt to define sports was preceded by our discovery of a rather little known fact. It is that art competitions were a part of the modern day Olympics for more than three decades, spanning from 1912 to 1948 as described in Stanton (2000). The inclusion and the eventual exclusion of art competitions in what is today considered the citadel of sporting events caught our attention. The reason for discontinuing art competitions can be traced to the institution’s emphasis on ‘amateurship’ on the part of the participants. ¹ Artists were considered established professionals whereas sports persons were considered ‘amateur gentlemen’. Although the reason to exclude did not stem from the debate if sport is an artform, the question seemed worthy of our perusal.

We took note of the literature on this debate - primarily carried on by two scholars Best (1980, 1985) and Wertz (1979, 1984, 1985), the former on the side of the debate that Sport is not an artform and the latter on the side that pursued the idea that Sport is art. Both the scholars, either proposed or followed prior definitions of art at various stages in their discourse to support their claims. These definitions were primarily borrowed from Saw and from her work in Saw (1972). In doing so, the lens through which they perceived sports was tinted by the definitions of art, art forms and aesthetics. This debate had not had a conclusive end to put the question to rest. Other scholars like Kovich (1971), Platchias (2003) and Corder (2012) also wrote on this question, which facilitated new avenues of discussing this debate.

We wanted to take these insights into consideration, but also extend it in a definitive manner by taking a different approach. One of the characteristics of the existing discussion on this debate is that it does not scrutinise sport as its own concept or domain. Sport is always studied in relation to existing definitions of art. Attempts to define sports are done so in the context of art and aesthetics - either in a correlation or as a negation as shown in Best (1980); Wertz (1979). But the nature of the question demands such juxtaposition of ideas of art and aesthetics onto sport. To move away from this approach, we decided to answer - ‘What is Sport?’ - a question that does not require comparisons to art as portrayed in previous scholarly work.

¹ See <https://www.smithsonianmag.com/arts-culture/when-the-olympics-gave-out-medals-for-art-6878965/>

Our approach to answer this question was that of graphical representation and analysis. We wanted to break down a few instances of the sport domain into its constituent elements and represent them in a graph. We wanted to examine the insights such an exercise would deliver. For doing so, we listed the ‘Events’ that constitute a sport. We defined an ‘Event’ of the gameplay of a sport as one that brings about a state change in the gameplay. These events were tracked with the help of the changes in the ‘Serializable factor’. We define Serializable factor as the aspect of the gameplay which should be tracked to make sense of the progress of game play.

In our case we chose the following sports - Hurdles, Shot Put, Badminton, Weightlifting and Synchronised Swimming. We chose this sample out of the sports that were included in the Olympics. As Olympic sports have an established standard of rules for the games, it would provide us a benchmark to track the rules and regulations involved in each sport. Moreover the selected sports have varied enough aspects in them that it would be sufficient to test out our exploratory method and analysis.

The serialisable factors for the sports Hurdles, Shot Put, Badminton, Weightlifting and Synchronised Swimming are the athlete, the shot, the shuttlecock, the athlete and the swimmers respectively. The serialisable factor/s(SF) prompts the changes in the state of the game play, which is why following the SF is necessary for following the gameplay. For example, the shuttlecock in Badminton is the SF, following the shuttlecock gives us a sense of the progress of the game play, of the state changes than following any of the players. If we were to track the gameplay, by following any of the players, we would end up with an incomplete picture of the gameplay. But following the shuttlecock, within the gameplay of Badminton allows us to traverse through the gameplay and keep track of the state changes. Serializable factor helps defining the ‘Events’ that make up the gameplay, if not for the SF, any minuscule changes by the actors of the sports network could end up as a node of the graph leading to redundancy and overpopulation of the graph. For the purpose of the exercise at hand, we defined the ‘Serializable Factor’, which helped in defining the ‘Event’ in a concise and exhaustive way. This way we listed the elementary blocks of activity(Event) and represented them as the nodes of the graph. The nodes of the graphs were connected based on the ‘Event Rules’ and ‘Game Rules’ of a sport. ‘Event rules’ are those rules that govern specific events of the gameplay whereas ‘Game Rules’ are applicable to all events of the gameplay.

While listing the Serialisable factor, the events, event rules and game rules; it becomes apparent that having an exhaustive list of events of a sport is essential for populating a graph. For sports like Synchronised Swimming, although the rules of the sport can be listed, the events cannot be predetermined - as a result any graph reproduced without a predetermined list of events is not exhaustive when compared to the other sports in the sample. Other sports taken into consideration like Hurdles, Shot Put, Badminton and Weightlifting can be represented as graphs as an exhaustive list of events that constitute the game play is possible. The graph is then constructed with these events as the nodes and the edges as the rules represent all the possible sequence of events the gameplay could progress in. This representability of sports in a graph means that either a sport can be Serialiazable or Unserializable.

This leads us to the first insight our approach has helped us arrive at. In the earlier mentioned literature on the Sport-Art conundrum, David Best uses definitions of art and aesthetics and utility to arrive at a classification of sports - Purposive and Aesthetic. We propose that representability of a sport in a graph determines whether the sport is a Purposive sport or an Aesthetic sport. Shot Put, Hurdles, Badminton

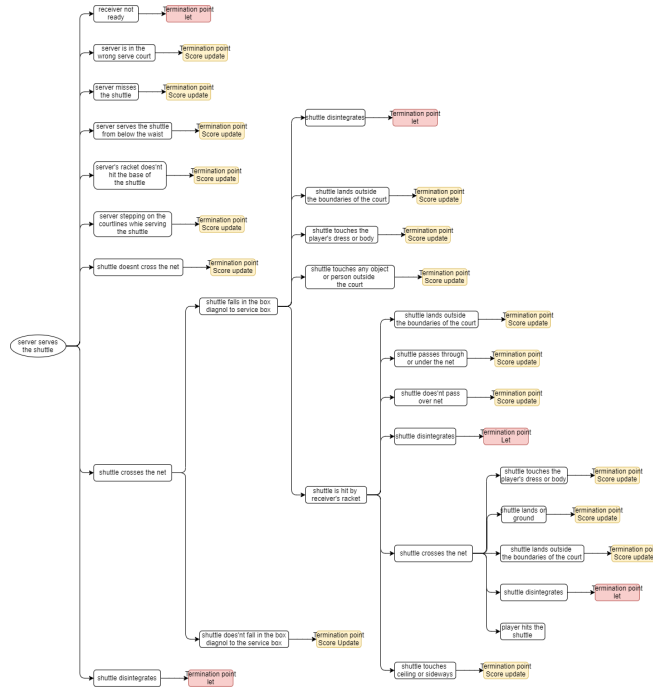


Figure 1: Graphical Representation of Badminton

and Weightlifting are all sports that Best would have classified as Purposive. All these Sports have in common that they are represented in the form of a graph. On the other hand, Synchronised swimming is a sport that would be classified as an Aesthetic Sport by Best and it also cannot be represented in a graph. Although our sample for this paper is quite small, we can extend this hypothesis to other aesthetic sports like Vault, Diving, Floor exercises etc, that are all aesthetic sports but cannot be represented in a graph. In other words, Serializable sports are Purposive and Unserializable are Aesthetic sports.

This is an interesting insight to take note of because it outlines one of the merits of using graphical representation in scrutinising sports. We arrived at the same classification that was previously established by Best but without the help of his argument that was based in definition of aesthetics and art. Graphical representation allowed us to gaze at sports as a domain in itself, not in relation with art but we arrived at the same classification. The meanings associated with our classifications are different owing to our approaches, but nonetheless, the contents of both our classification are similar. The graphical representations of Serializable sports are shown in Figures 1,2,3 and 4.

The second insight from this sort of representation of sport is that it makes possible the tagging of sport content with the specific event. At every notation of a tag, the possible outcomes of the gameplay is already outlined in the graph. This way these graphical representations can be used to populate the metadata of sports content. This metadata could be helpful in making a gameplay machine accessible and readable. By that, we mean that domain ontology of sports can be constructed using graphical representations.

We also formulated the grammar of serialisable sports in a bid to work towards domain ontology. The graphs of serialisable sports that were taken into considera-

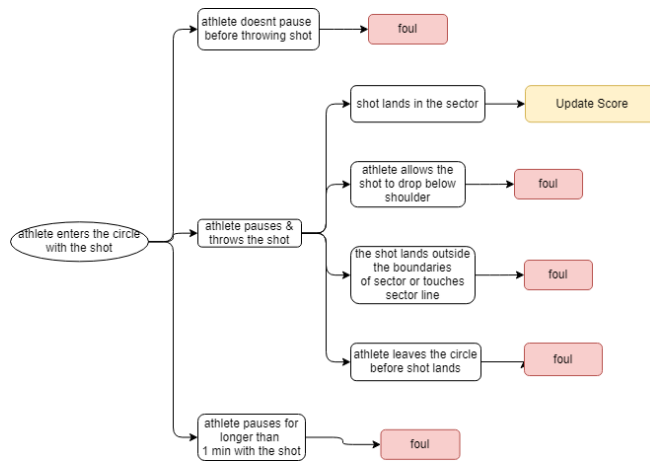


Figure 2: Graphical Representation of Shot Put

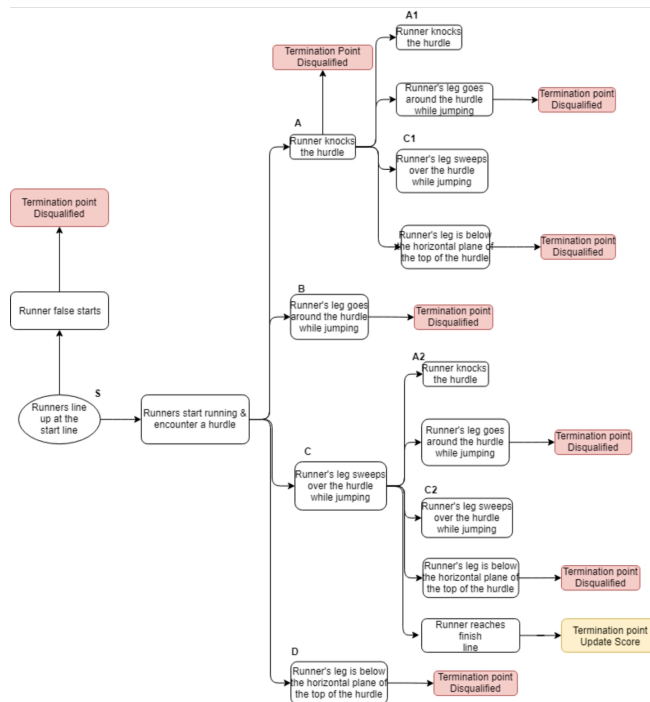


Figure 3: Graphical Representation of Hurdles

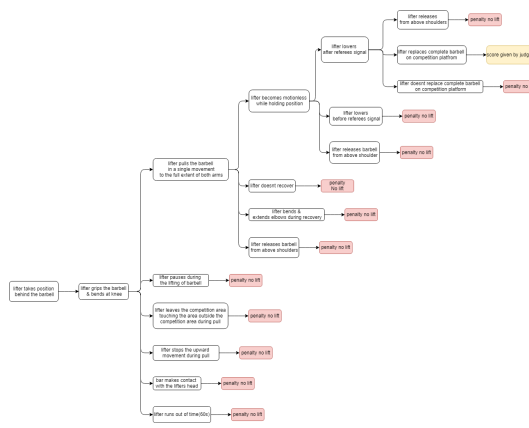


Figure 4: Graphical Representation of Weightlifting

tion, are a visual representation of those sports, in terms of nodes and edges. It is a formal system that is governed by rules, and goes through state changes in the game-play to reach a final state (win/loose/draw etc). In other words these sports display sequential logic and are in a finite number of states before reaching the final state. This lead us to consider representing serialisable sports as a finite state machine or automaton(FSM/FSA) and their recognisable languages. The FSM's and the regular language expressions of the sports taken into consideration. Figures 5,6,7 and 8 depict the state diagrams of the serializable sports. Table 1,2,3 and 4 help in elaborating the the state diagrams. Equations 1,2,3 and 4are derived from the state diagrams and provide the basis for the formal notation of sports in a domain ontology.

Finite State Automaton of Badminton (V)

The State Diagram for Badminton which is derived from the FSA is depicted in Figure 5.

$V = (Q, \delta, \Sigma, q, G)$ where

- $Q = \{S, A, B, C, D, E, F, G, H\}$ where
 - Q is the set of all the possible states that a game of Badminton could exist in.
 - S – Starting State, Player 1 takes position to Serve
 - A – Shuttle in rally either due to successful Serve by Player 1 or successful hit with racket by Player 1.
 - B – Faulty Serve by Player 1
 - C – Shuttle in Rally due to successful hit by Player 2
 - D – Rally interrupted due to faulty hit by Player 2
 - E – Rally interrupted due to Player 2 letting the Shuttle drop to the ground
 - F – Score Update
 - G – Rally interrupted due to faulty hit by Player 1
 - H – Rally interrupted due to Player 1 letting the Shuttle drop to the ground
- $\Sigma = \{s, f, h1, h2, r1, r2, d1, d2, p1, p2, l\}$ where
 - Σ the set of all possible actions by the players of a game of badminton.

Table 1: Transition Function of Badminton

Initial State	Input	Final State
S	l	S
S	s	A
S	f	B
A	h2	C
A	d2	E
A	r2	D
B	p2	F
C	r1	G
C	d1	H
E	p1	F
D	p1	F
G	p2	F
H	p2	F

- s - Serve
- f - Faulty serve by player 1
- h1 - Shuttle hit by Player 1
- h2 - Shuttle hit by Player 2
- r1 - Faulty hit by Player 1
- r2 - Faulty hit by Player 2
- d1 - Shuttle dropped by Player 1
- d2 - Shuttle dropped by Player 2
- p1 - Point to Player 1
- p2 - Point to Player 2
- l - let

- $q = \{S\}$
- $G = \{F\}$
- δ - Transition Function that dictates how the states of the game changes depending upon the actions taken by the player

Regular Language of Badminton

$$R = lfp2 \mid ls(h2h1)^*d2p1 \mid ls(h2h1)^*r2p1 \mid ls(h2h1)^*h2r1p2 \mid ls(h2h1)^*h2d1p2 \quad (1)$$

Finite State Automaton of Shot Put (S)

The State Diagram for ShotPut which is derived from the FSA is depicted in Figure 6.

$S = (Q, \Sigma, \delta, q, F)$ where :

- $Q = \{S, A, B, D, F\}$ where

Table 2: Transition Function of Shot Put

Initial State	Input	Final State
S	f	D
S	t	A
A	h	D
A	s	B
B	m	F

- Q is the set of all possible states that a game of Shot Put could exist in.
- S is the starting state where the player takes position
- A - Shot is thrown
- B - Shot has landed
- D - Player is disqualified
- F - Final State / Player score is updated
- $\Sigma = \{t, f, s, h\}$ where
 - Σ is the set of all actions that the players of Shot Put can take during the game play.
 - t - Player throws the shot
 - f - faulty throw by a player
 - s - shot lands
 - h - shot lands outside the sector
 - m - Space is measured between Player and Shot
- $q = \{S\}$ where q is the starting state of the game play of Shot Put
- $G = \{D, F\}$ where
 - G is the set of all final states of the game play of Shot Put
 - D - Player is disqualified
- δ is the transition function dictated by the rules of Shot Put. The transition function lays out the state changes in the game play of Shot put depending upon the action taken by the player.

Regular Language of Shot Put

$$R = f|th|tsm \quad (2)$$

Finite State Automaton of Hurdles(H)

The State Diagram for Hurdles which is derived from the FSA is depicted in Figure 7.

$H = (Q, \Sigma, \delta, q, G)$ where:

- $Q = \{S, A, B, C, D, F\}$

- Q is set of all states that the sport of Hurdles can exist in.
- A - Player is in Running state
- B - Player crosses a hurdle
- C - Player reached the end line successfully while adhering to the rules.
- D - Disqualified
- F - Final State / Score update for Player
- $\Sigma = \{r, f, v, u\}$ where
 - Σ is the set of all actions that the players of Hurdles can possibly take
 - r - running
 - f - false start
 - v - valid jump
 - u - faulty jump
 - m - measure time taken
- $q = \{S\}$
 - q denotes the starting state of Hurdles
- $G = \{D, F\}$
 - G is the set of all accepting or final states of the sport
 - D denotes that the player is disqualified
 - F denotes that the player's score is updated.
- σ is the transition function defined by the rules of Hurdles. This function dictates how the state of sport changes from one to another depending upon the action taken by the player. The transition function of Hurdles is given in Table.1

Table 3: Transition Function of Hurdles

Initial State	Input	Final State
S	f	D
S	r	A
A	u	D
A	v	B
B	r	C
B	r	A
C	m	F

Regular Language of Hurdles

$$R = f|rvr(vr)^*m|r(vr)^*u \quad (3)$$

Finite State Automaton of Weightlifting (W)

The State Diagram for Weightlifting which is derived from the FSA is depicted in Figure 8.

$W = (Q, \delta, \Sigma, q, G)$ where

Table 4: Transition Function of Weightlifting

Initial State	Input	Final State
S	l	A
S	f	D
A	p	B
A	q	D
B	s	F

- $Q = \{S, A, B, D, F\}$ where
 - Q is the set of all possible states that round of Weightlifting could possibly be in.
 - S - Starting State / Lifter takes position
 - A - Barbell is lifted
 - B - Barbell is lowered
 - D - Disqualified
 - F - Score is Updated
- $\Sigma = \{l, f, p, q, s\}$ where
 - Σ is the set of all actions that a player can taken during the course of the sport.
 - l - Player lifts the barbell according to the rules
 - f - Player does a faulty lift (does not adhere to the rules while lifting)
 - p - Player lowers the barbell according to the rules
 - q - Player breaks rules while lowering the barbell
 - s - Judges score the player
- $q = \{S\}$ where q is the starting state of a round of Weightlifting
- $G = \{D, F\}$ where
 - G is the set of all possible final states of a round of weightlifting
 - D - Player is disqualified
 - F - Score updated
- δ is the transition function of Weightlifting. It dictates the state changes a round of Weightlifting must take depending upon the actions of the lifter.

Regular Language of Weightlifting

$$R = f|lq|lps \quad (4)$$

The ontology we referred to so far is that of a ‘domain ontology’. Computer scientists like Breitman (2007), Kalfoglou and Schorlemmer and Poli and Obrst (2010) have coined this term in a bid to make instances of knowledge machine accessible and understandable but ontology as a line of questioning is rooted in the discipline of

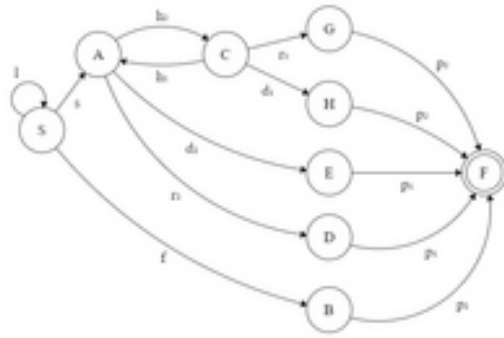


Figure 5: State Diagram of Badminton

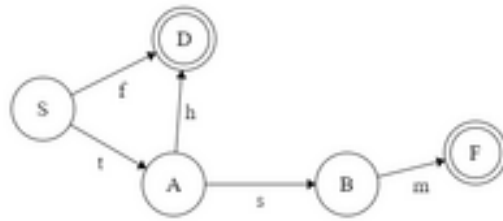


Figure 6: State Diagram of Shot Put

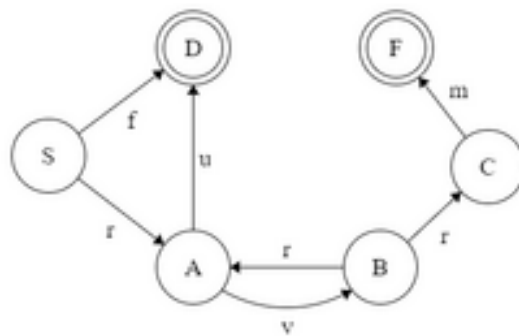


Figure 7: State Diagram of Hurdles

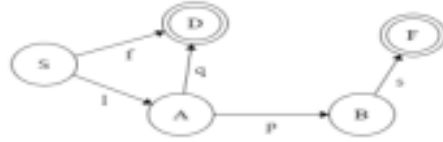


Figure 8: State Diagram of Weightlifting

philosophy that deals with the nature of being. The question we are trying to answer ‘What is Sport?’ is an ontological question. The approach taken to study it is that of studying the structure of sport by representing them in graphs - essentially trying to answer an ontological question by analysing structure. While the insights gained point that there are merits to this method there are certainly limitations as well.

If we were to study sports as a social institution, it becomes apparent that there are other actors within the framework of sport. Sport has been studied in this direction in the works of Eco (2014) and Orwell (2018). In the graphs constructed so far, the prominent actors are players. But a sporting event cannot be imagined without spectatorship. Just as much as the players are a necessary part of sport, without the sporting event being broadcast to an audience, it falls short of qualifying as sport and will only be a game. We propose that the ontology of sport is not just limited to the gameplay (events and rules) but must also include the networks of the audience, the meanings they associate with the events, the various ideas of regionalism, nationalism, elitism etcetera that sporting events fuel and manifest.

Graphs definitely aid in representing the network of audience and in capturing the reach of a sporting event. With graphical representations of the various actors involved, will it be able to document the myriad of meanings and connotations attached to a sporting event is a question to be pursued in the future.

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