International Journal of Engineering Inventions
e-ISSN: 2278-7461, p-ISSN: 2319-6491
Volume 6, Issue 6 [June. 2017] PP: 04-14

Inventive Dynamic Concentric Areas Surrounding the Balloon for Controlling Soccer Players' Abilities

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Abstract: Soccer team's behavior and interactions between the players need a creative spatial analysis approach by designing an inventive concentric distribution of players surrounding the balloon. Three fundamental concepts of the Theory of Inventive Problem Solving (TRIZ) were applied in order to control and involve continuously individual players into the collective game. Spatial observations of relevant matches' sequences were analogically analyzed to identify hierarchical execution of individual tactical, physical and technical abilities. The concept of dynamic concentric areas surrounding the balloon (DCASBs) was introduced by analogy to gradients of mechanical and chemical phenomena surrounding biocatalyst. This concept that comes to ensure the continuity of the play in the time is compatible with the different systems of play that manage the complementarities between the lineups inside the team block. The creative DCASBs using TRIZ constitutes a good way for the player's tactical skills evaluation and the analysis of soccer game. This concept which is the third inventive finding throughout the history of soccer after the offside rule and systems of play could be a tool to human resources management for planning, organizing directing and controlling of the human activities to the end that individual tasks are executed.

Keywords: *Football, TRIZ, dynamic concentric areas, lineups, players' abilities control*

I. INTRODUCTION

The soccer game resulted of the movement of the balloon and players acting tactical, physical and technical abilities. Tactical behavior can be defined as the individual and collective actions of a team to best employ player skills in order to contribute to the team's goal of attacking and defending by goal scoring or preventing goals [1]. Soccer formations are the way a team lines up its defense, midfield, and forward line at the beginning of the match. Tactical behavior in team sports has been evaluated in previous research by tracking the movement behaviors of players on the pitch. Measuring the oscillation between the centers of gravity of teams allows to better understanding the balance between teams on the field, the variation on the flow of the game and the level of coupling between teams [2-4].Soccer game is a good model that shows the success of an individual task in a local situation related to a general context. It was mentioned that future analysis of tactical behaviors of players and teams in soccer needs to account with the effect of pitch location on players and teams' behavior [5]. However, the soccer still appears very complex and the game is unpredictable because the number of possible combinations is very high but only one path of movement of the ball will be performed. Indeed, over the last years, there were some attempts to improve the understanding of the tactical aspects of the football game and practice tasks by considering the interactions between opposing players and/or teams [6]. Currently, the small-sided games (SSG) are very popular training drills for all ages and standards of play given that, presumably, they concurrently improve players' physical conditioning, technical and tactical skills [7]. Spatial–temporal patterns of such variables provide more detailed information on the type of interaction between teams. In-phase pattern is reported to be dominant in small-sided games [8] and full-sized matches [9]. Several tactical performance measures offers insight in tactical behavior accounting for pitch location. McGarry [10] mentioned that pitch location not only constrained the local players relations between attackers and defenders [11] but also the relationship developed between teams. Tactical skills evaluation remains subjective and confuse because abilities are evaluated through many dimensions simultaneously. Moreover, the soccer game analysis remains limited because the currently game systems used to organize team remain insufficient and need innovation to define much more the responsibilities of the players and help them to contribute continuously into the collective game. Numerous new developed processes demonstrate that substantial innovations often result from analogical thinking [12] to transferring problem solutions from one domain to another as bionics, analogy and TRIZ approaches [13-15]. In the present work, the three fundamental concepts of the Theory of Inventive Problem Solving were applied on soccer game during analytical thought steps: (i) anticipation future ways of football game evolution into more controlled game, (ii) solution was based on the ideal final result (IFR) to integrate continuous individual player activities into collective game and (iii) inventive solution overcomes some identified contradictions by standing near solutions.

II. METHODOLOGY

The inventive design method is rooted in the TRIZ theory. TRIZ is the Russian acronym for Teoria Rechenia Izobretatelskih Zadatchi that in English means Theory of Inventive Problem Solving (TIPS). To create TRIZ in 1996, Genrikh Altshuller had conducted scientific observations and a huge analysis of numerous patents (400,000) related to technology and engineering [16]. TRIZ is a knowledge-based systematic methodology which helps to identify problems, develop systems and find possible solutions. As a technique that effectively resolves contradictions related to engineering problems and that reaches a balance/consensus among different interests, TRIZ has been rapidly and widely adopted in the academic and industrial domains. The procedure of the theory of inventive problem solving, its tool sets and its thinking approach are the main categories of TRIZ applications in innovation projects, developing breakthrough conceptual ideas and practical solutions [13].

In fact, TRIZ tools are independent of the field of discovery in order to facilitate trans-disciplinary knowledge transfer and to reach solutions with a higher level of innovation using inter-domain analogies. Then, the generic solutions should be adapted to the specific initial problem according to the specific conditions and constraints. As a consequence, TRIZ operates through generic models i.e. patterns of problems and solutions and not by spontaneous creativity of individual groups [17]. Modern TRIZ has evolved from a methodology used to solve technical problems to a method that increasingly incorporates tools to analyze initial problem situations before deciding on core problems formulating contradictions and problem solving. One of the tools assimilated into TRIZ is the root cause analysis in its various forms and derivatives: Fishbone or Ishikawa diagram, cause effect chain analysis and root conflict analysis [18].

In the present work, the main stages of the program applied were: defining the goals, detecting the problems, identifying the contradictions, searching for possible strategies, proposing appropriate solutions and finally developing the inventive design. This is a famous program called 40 inventive principles management system in which TRIZ places 39 technical parameters, identified through patent analysis, into a Altshuller's Contradiction Matrix. It also outlines 40 principles of creative invention to resolve the contradictions, and solutions are achieved by matching the contradiction with its appropriate principle. Then, the inventive principles deliberately taken on a very general form should therefore always be fitted to the specific conditions of the analyzed problem. The inventive principles (Table 1) stimulate creative multidirectional multiplex thinking, or suggest a ready solution [19]. Observations and analysis of some sequences of some excellent soccer matches have been used to confirm this inventive idea of DCASBs in attacking, defending and transition phases (Table 2).

Table (1) Examples of inventive principles of TRIZ stimulating creativity used in solving problem of soccer collective game.

Principle/ TRIZ tools	Functions
1 Segmentation	Stratification of different constituents
3 Local quality	Change of an object's structure from uniform to non-uniform
5 Merging	Make objects or operations contiguous or parallel; bring them together in time
7 Nested dolls	Place one object inside another
15 Dynamics	Change the object for optimal performance at every stage of operation
20 Continuity of useful action	Carry on work without a break. All parts of an object operating constantly at full capacity
33 Homogeneity	Objects interacting with the main object should be of same material
36 Phase transitions	Use phenomena of phase transitions

Table (2) Examples of sequences game ended by goal where DCASBs approach is perfectly applied in defending, attacking and transitions phases.

Match	Date	Final score	Sequences
FCB vs Juventus	2015	3 - 1	3 th goal
FCB vs Man City	2014	2 - 0	2 nd goal
Milan AC vs FCB	2013	0 - 4	1 st goal
FCB vs Bayern	2015	3 - 0	1 st goal
Dortmund vs Schalke	2015	3 - 2	1 st goal
Dortmund vs Bayern Munich	2013	0 - 3	1 st goal

Dortmund vs Napoli	2013	3 - 1	2 nd goal
Holland vs Spain	2014	5 - 1	1 st and 2 nd goal
Brazil vs Germany	2014	1 - 7	6 th goal
Germany vs Argentina	2010	4 - 0	4 th goal

FCB: Fútbol Club Barcelona; **Milan AC:** Associazione Calcio Milan.

III. RESULTS

The problem of collective football game control may be expressed in the form of elementary contradictions. A contradiction arises when two requirements or performances for a collective game are mutually exclusive but both must be associated to reach the game objective. An inventive problem contains at least one contradiction and an inventive solution. In TRIZ, the conventional trade-off is refused and the invented solution tries to overcomes totally or partially the identified contradiction.

Four couples of contradictions were indentified in soccer collective game (specific problem): (1) Individual game and collective game, (2) Players' activities near and far of the balloon (3) Small sided-games and full sized-game, (4) Local numerical superiority and global numerical superiority; and they are similar to those formulated for the Biochemical process (generic problem), and used to break psychological inertia during formulation (Fig. 1). The essential biochemical process characteristics were used during interpretation steps (generic problem) to solve the four couples of identified contradictions in soccer collective game, and then to design three dynamic concentric areas surrounding the balloon (generic solution).

The idea of DCASBs was introduced by analogy to gradients of mechanical and chemical phenomena surrounding biocatalyst involved in the bioprocesses behavior and performances (Fig. 2). The overall rate of substrate consumption is limited by the following three barriers: diffusion of substrate from bulk of liquid to the biofilm, diffusion of substrate within the biofilm, and biochemical reaction [20]. Similarly, movements of surrounding players of the ball possessor can affect those of further surrounding players, and finally affect whole team. The same phenomena are observed with soccer game where movements of players in tactical dynamic concentric areas (TaDCA) and physical dynamic concentric areas (PDCA) limit players' technical abilities in technical dynamic concentric area (TDCA).

Each characteristic of biochemical process was used to control each couple of contradiction in soccer game (Fig. 1) thanks to DCASBs (specific solution):

(1) Continuous hierarchical involvement of each player into the collective game,
(2) Gradient player's abilities surrounding the balloon,
(3) Player's abilities change through DCASBs,
(4) Management of numerical superiority regarding DCASBs.

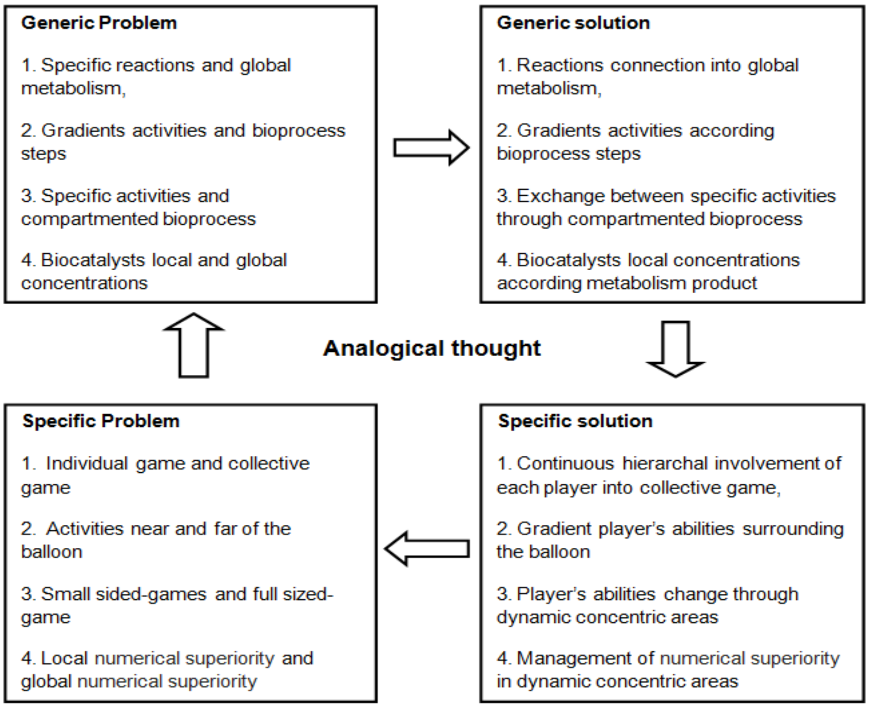

Fig. (1) Application of TRIZ problem solving to obtain an inventive spatial distribution of players through DCASBs for controlling football game play.

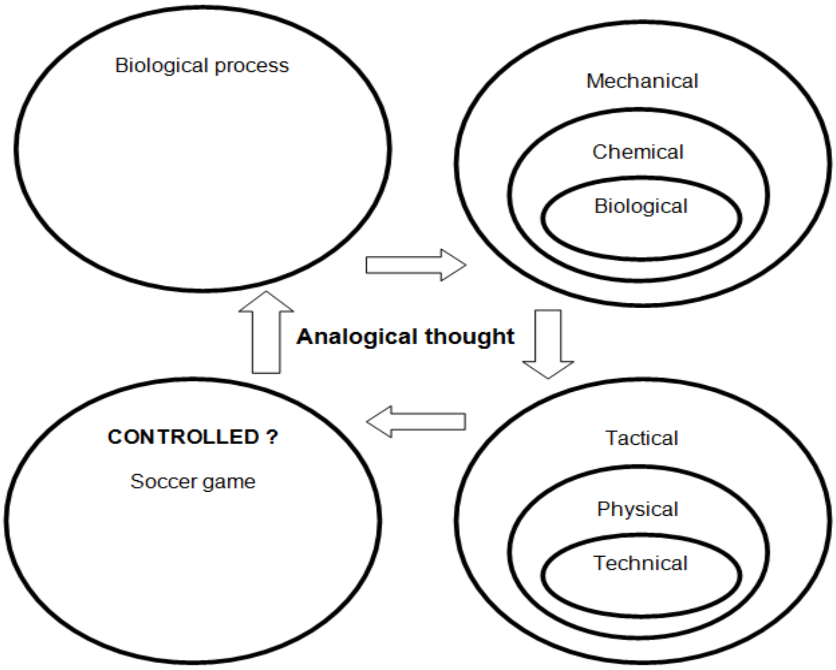

Fig. (2) Analogies between controlled bioprocess and soccer game.

Figure 3 shows how this concept of DCASBs defines clearly the individual tasks of the players in the football game through TaDCA by using tactical skills for planning and positioning, through PDCA to mobilize their physical abilities, and finally in TDCA for carrying good technical gesture abilities to master the balloon.

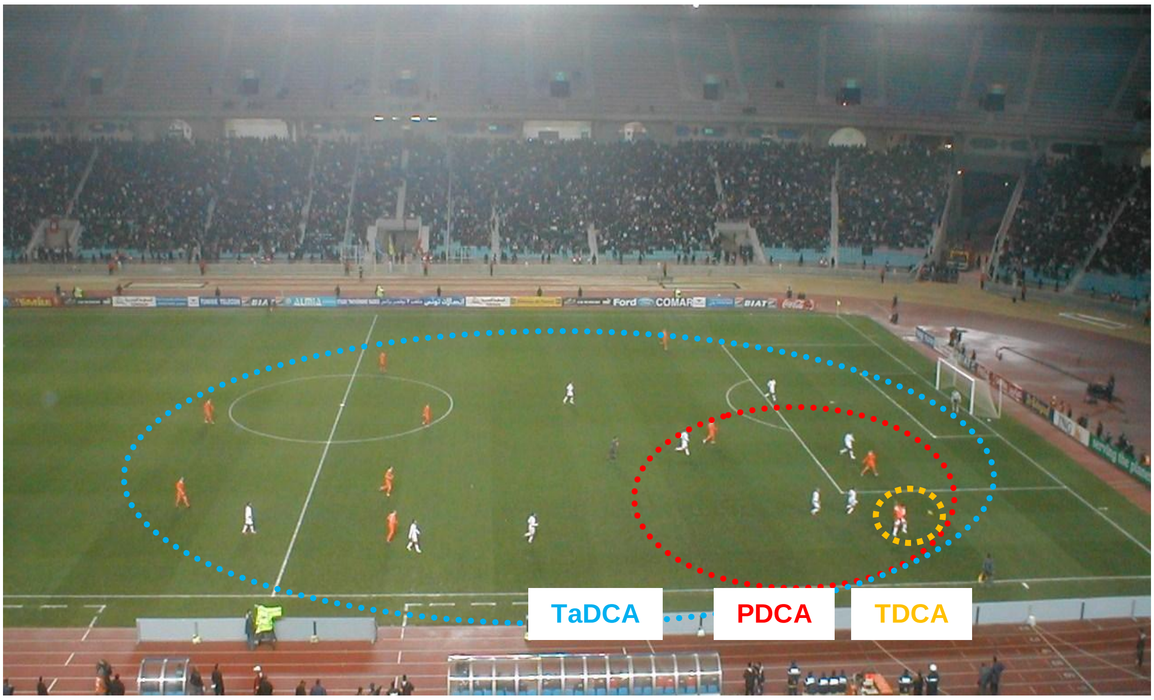

Fig. (3) Example of distribution of soccer players in team block through DCASBs during friendly match Tunisia vs Netherlands at the stadium of Rades (Tunisia) 2009. **DCASBs:** Dynamic concentric areas surrounding the balloon; **TaDCA:** Tactical dynamic concentric areas; **PDCA:** Physical dynamic concentric areas; **TDCA:** Technical dynamic concentric area.

The first goal marked by Messi (FCB vs MSU, 2016) illustrates the perfect individual tactical behavior since TaDCA, excellent movement through PDCA to receive the ball and mark the goal in TDCA. The analysis of ratio of both team players through DCASBs (Fig. 3, Table 3) shows that the player who has possession of ball didn't have option to pass the ball in PDCA, and he tried to surpass the defender in TDCA in order to pass the ball little further.

Table (3) Example of distribution of soccer players through lineups and DCASBs for both teams (Ratio : Netherlands in offensive situation /Tunisia in defensive situation) according Fig.3.

		DCASBs			Total
		TaDCA	**PDCA**	**TDCA**	
Lineups	D	4/2	-	-	4/2
	M	2/2	1/1	-	3/3
	O	1/1	1/3	1/1	3/5
Total		7/5	2/4	1/1	10/10

D: Defensive; **M:** Midfield; **O:** Offensive. **DCASBs:** Dynamic concentric areas surrounding the balloon; **TaDCA:** Tactical dynamic concentric areas; **PDCA:** Physical dynamic concentric areas; **TDCA:** Technical dynamic concentric area.

The management of players through simultaneously lineups, DCASBs and team status will be an original tool to analyze and control the different situations of games. Indeed, the system formation like 4-2-2 manages the complementarities between the players through positioning and movement inside team block, while the concept of DCASBs comes to ensure continuously the involvement of all players in the game through mobilization of required abilities in whole situations of game. The management of soccer players' abilities through the DCASBs which responsibilize the players is perfectly compatible with the different systems of play.

Table 4 summarizes the parameters of the game that greatly increase the hierarchization of the soccer game on the basis of DCASBs. TaDCA contributes to the game up to 80 % by a number of players that can go up to 16 on a surface diameter that can exceed 60 meters. PDCA contributes to game with a maximum of 20 %, by a number of players up to 10 on a surface diameter of up to 30 meters. The TDCA with reduced diameter of a few meters is the spot of execution of individual technical gesture to master the balloon whose contribution in the game does not exceed 5 %. For kicks, the number of players in TDCA could exceed three depending on the size of the wall.

The coordination through DCASBs is beneficial because it should increase the technical and tactical volume at the expense of the volume of physical intensities in defensive and attacking situations. Specifically, coaches can use the heart rate (% HR max) to quantify internal loads of oxygen uptake (%VO_2 max) and subsequently implement continuous endurance training at appropriate intensities [21]. The type of individual or collective defense and attacking is clearer and better defined by the concept of DCASBs. The marking and attacking the ball carrier are often individual task in the TDCA, while collective defense is mixed between marking and tightening in PDCA. In the TaDCA, collective defense is zonal for covering pressuring defenders. The relay of individual ball possession through serial TDCAs is conditioned by the collective game developed by the team in the PDCA and TaDCA.

Table (4) Arguments of the distribution of soccer players through the concept of DCASBs.

Game parameters	**DCASBs**		
	TaDCA	**PDCA**	**TDCA**
Area diameter (m)	30 – 60	10 – 30	2 - 10
Number of players	4 – 18	2 – 10	1 - 2
Principal tasks	Positioning	Support	Gesture
Mental resources	Thinking	Emotion	Sentiment
Organic body	Brain	Herat (GRINTA)	Body membres
Communication level	Very high	High	High
Physical resources	Endurance	Resistance	Intensity
Speed (Km/h)	0 -10	10 – 20	> 20
VO_2 max (%)	30 – 90	> 90	> 100
Game contribution (%)	60 – 80	10 – 20	2 - 5

DCASBs: Dynamic concentric areas surrounding the balloon; **TaDCA:** Tactical dynamic concentric areas; **PDCA:** Physical dynamic concentric areas; **TDCA:** Technical dynamic concentric area; **VO_2:** Oxygen uptake.

Considering the team in advantage (A) with ball possession (BP) and in disadvantage (DA) with no ball possession (NBP), we obtain eight possible game situations (2^3) through the three DCASBs: four defensive situations and four offensive situations. Nevertheless, if we consider the interactions between opposing individuals players with considering advantage and disadvantage without the DCASBs concept, the number is very high and that why prediction of game is impossible. Table 5 shows the four defensive game situations where the team is not in possession and it describes the status of the team in the DCASBs: advantage. The organization of defense in concentric areas allows the ball holder harassment in the TDCA, tightening and closing in the PDCA and the preventive organization in the TaDCA by covering partners and monitoring of opponents.

Table (5) Different defensive game situations (No Ball possession) through the three DCASBs.

Defensive situations		**DCASBs**			
		TaDCA	**PDCA**	**TDCA**	**Control of game**
1	Defensive withdrawal, tactical error	DA	DA	DA	Uncontrolled game and domination by opponent
2	Cover and defensive withdrawal	A	DA	DA	Timing and localization of the opponent team
3	Brake hindsight pressure and mixed marking	DA	A	DA	Ball carrier isolation and risk of reversal game
4	Attack the ball carrier, pressure, sliding and coverage	A	A	DA	Start of opponent ball carrier control and ball recovery preparation

A: Advantage; **DA:** Disadvantage.
DCASBs: Dynamic concentric areas surrounding the balloon; **TaDCA:** Tactical dynamic concentric areas; **PDCA:** Physical dynamic concentric areas; **TDCA:** Technical dynamic concentric area.

Table 6 shows the four attacking game situations where the team is in possession of the ball and summarizes the status of the team in the DCASBs. Exchange of the balloon depends on the placement of the teammates in TaDCA and in PDCA on the one hand, and the individual gesture quality of the ball carrier and the technical shortcomings of the defender on the other hand. Indeed, the presence of duels in TDCA reflects the disadvantage of ball carrier because the insufficient movement of teammates in TaDCA and in PDCA to supply solutions and receive the balloon.

Table (6) Different attacking game situations (Ball possession) through the three DCASBs.

Attacking situations		**DCASBs**			
		TaDCA	**PDCA**	**TDCA**	**Control of game**
5	Reception and delay, individual game	DA	DA	A	Ball carrier isolation
6	Counter attack or reversal game	A	DA	A	Long pass to overthrow the game
7	Quick attack or placed attack	DA	A	A	Progression of the balloon with support and risk of reversal game
8	Placed attack	A	A	A	Domination of the game

A: Advantage; **DA:** Disadvantage.
DCASBs: Dynamic concentric areas surrounding the balloon; **TaDCA:** Tactical dynamic concentric areas; **PDCA:** Physical dynamic concentric areas; **TDCA:** Technical dynamic concentric area.

Figure 4 shows that the number of players through DCASBs and through lineups (Defensive midfield and offensive) depends of the location of team block on the pitch and the team status (ball possession, non ball possession, and transition). The location of TDCA in central corridors increases the number of players in PDCA, while the location of TDCA in lateral corridors increases the number of players in TaDCA at the expense of PDCA (Table 7).

The 4-4-2 is the most common and known formation in today's modern game changes to 5–3–2 because the central midfielder tends to remain further back in order to help prevent counter-attacks. Indeed, the control of the number of players in the middle lines up that is in contact with all PDCA in majority of situation games should ensure the superiority. For instance, many German teams use the 3-6-1 formation in road games as they try to clog the opposition up in the midfield, attempting to pull off a tie or a win.

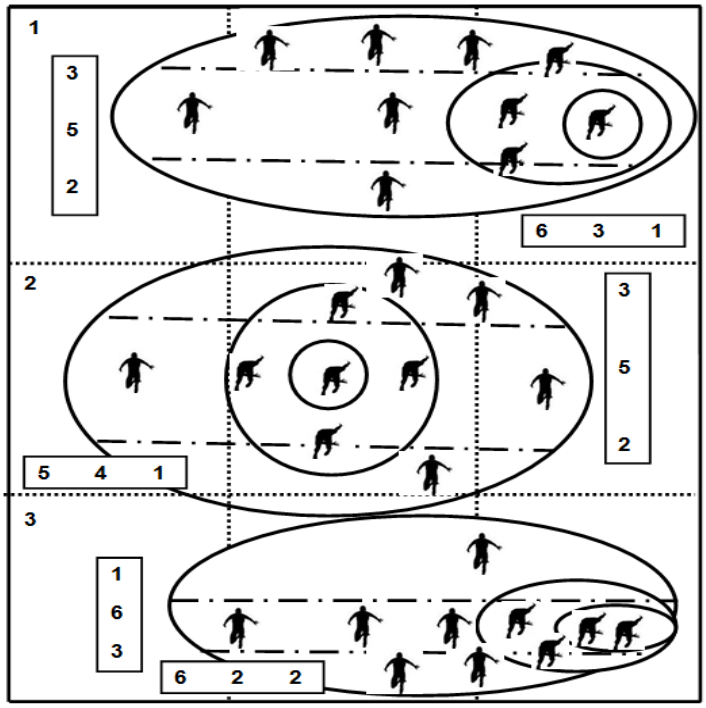

Fig. (4) Examples of distribution of soccer players in team block through lineups and DCASBs (offensive: 1 and 2, defensive: 3) at different locations of pitch.

Table (7) Examples of distribution of soccer players in team block through lineups and DCASBs (offensive: 1 and 2, defensive: 3) at different locations of pitch - Fig. 4

1 Offensive		**DCASBs**			**Total**
		TaDCA	**PDCA**	**TDCA**	
Lineups	D	3	1	-	3
	M	2	1	1	5
	O	1	1	-	2
Total		6	3	1	10

2 Offensive		**DCASBs**			**Total**
		TaDCA	**PDCA**	**TDCA**	
Lineups	D	2	1	-	3
	M	2	2	1	5
	O	1	1	-	2
Total		5	4	1	10

3 Defensive		**DCASBs**			**Total**
		TaDCA	**PDCA**	**TDCA**	
Lineups	D	2	1	-	3
	M	3	1	2	6
	O	1	-	-	1
Total		6	2	2	10

D: Defensive; **M:** Midfield; **O:** Offensive.
DCASBs: Dynamic concentric areas surrounding the balloon; **TaDCA:** Tactical dynamic concentric areas; **PDCA:** Physical dynamic concentric areas; **TDCA:** Technical dynamic concentric area.

The creation of the game through DCASBs in the attacking situation is opposite to that of the defensive situation, and can be well exploited in the game transition (Fig. 5). The movement of attackers in PDCA and in TaDCA offers solutions to receive ball from the ball carrier in TDCA. For cons, the behavior of the first defender in TDCA will determine the engagements of other defenders in PDCA to tighten spaces and for the covering the teammates in TaDCA. When ball possession changes, the defenders become attackers and attackers become defenders in the direction of creating the game. The defensive transition is triggered by the first defender in the technical area. For cons, the offensive transition is determined by the attackers' movements in the tactical area and in the physical area. In the physical area, the transition game is shared between the offensive opportunity and defensive security. The opposite direction of creating game during attacking and defending through DCASBs and transition phases between both teams is cyclic and then it ensures the continuity of the game.

Spatial observations of matches noticed that matches' sequences where dynamic concentric areas are perfectly applied in attacking phases lead to goal (Table 2). We observed also those goals resulted after good defensive action followed by offensive transition phase in one hand, and non defensive transition after lost of balloon by opponent team on the other hand.

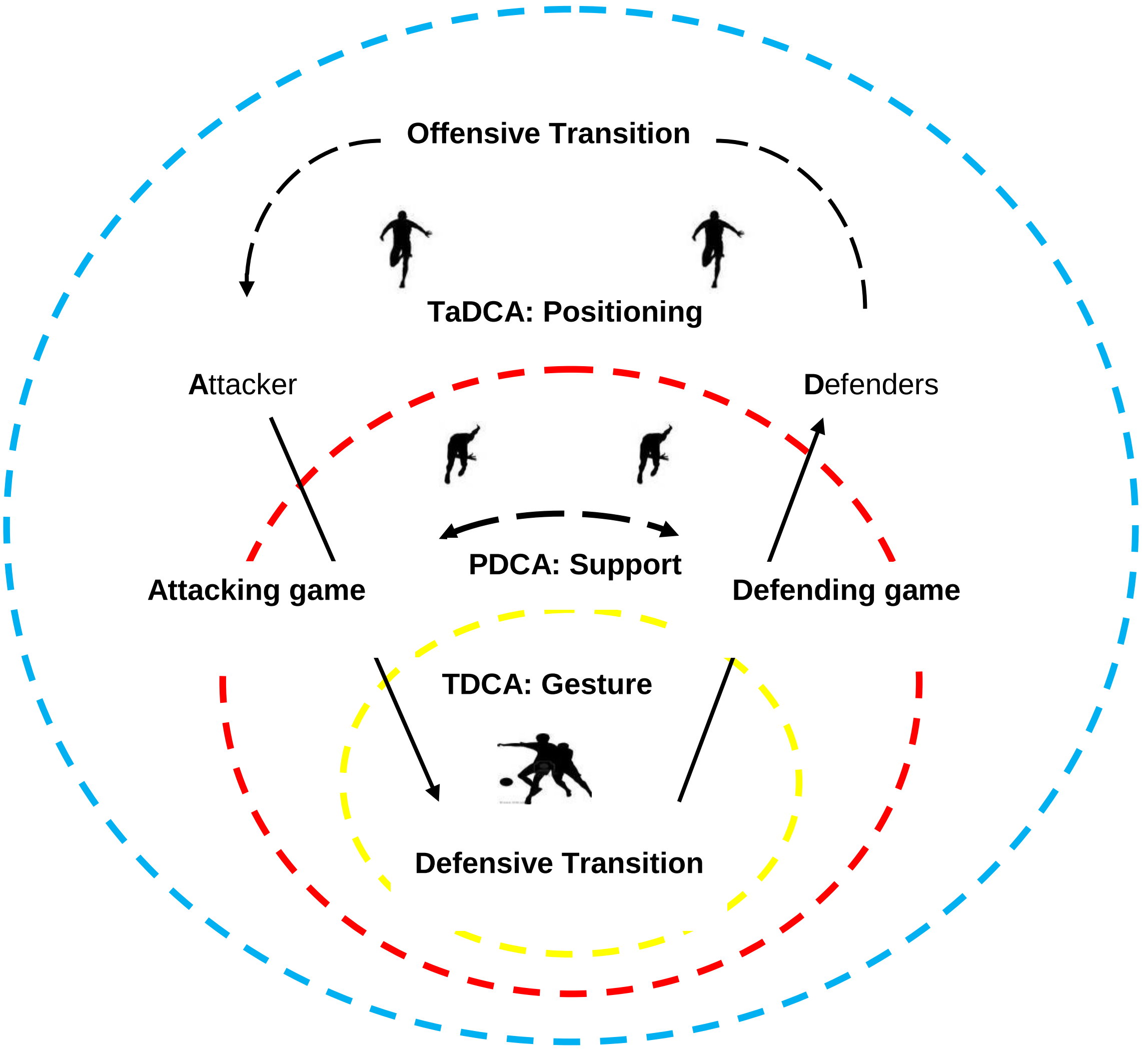

Fig. (5) Creating game cycle during attacking phases, defending phases and transition phases through DCASBs.

IV. DISCUSSION

The movement of soccer players inside the team block and the analysis of tactical behavior related to dynamic position of players should be referred to rational model like atom, cell, biofilm and planet... The concept of DCASBs constitutes a new way to manage soccer players' involvement in the game and to asses much more objectively their tactical, physical and technical abilities. The use of football players' dynamic positional data to assess tactical behavior by measuring movement patterns and inter-player coordination may open new research topics under the tactical scope and allow narrowing the gap between sports sciences and sports coaching [4]. Indeed, it was mentioned that evaluation of the development of tactical skills of elite youth football players showed that verbal reports are not a valid measure of tactical skills [22]. In the same way, Silva et al. [23] reported that training practice still have modest effects on intra-team synergies in soccer teams.

The global positioning system (GPS) monitoring of movement patterns is widespread in elite football noticed the increases in the physical demands [24]. The DCASBs concept is consolidated by the analysis of football spot by the technique of GPS showed that players spend on average 3.68 % of the time in the sprint, 11.37 % in rapidly running and 79.60 % in walking [25]. In the same way, Reilly and Williams [26] mentioned that football players are in possession of the ball for only 2-3 % of the duration of the match. In fact, the ranking of players is often criticized by the International Centre for Sports Studies (CIES) soccer observatory or by journalists, because evaluation is based especially on technical and physical abilities while 75 % of the tactical contribution is not taken into account. Indeed, the assessment of players' behavior through DCASBs constitutes a rational tool and comparison especially between Maradona and Messi becomes easier.

Ball possession related to physical and technical indicators highlighted the importance of distances covered (total, with and without BP), time spent in the attacking third and successful short passes during matches [27]. Previous analysis of the spatial–temporal principles that shaped successful passing interceptions showed that more passes were intercepted when the defenders were further away from the ball carrier and closer from the passing trajectory of the ball [6]. Recent relevant finding confirm that the tactical, physical and technical demands change with pitches size. Investigation of the effects of common rule changes on technical and physical demands for elite soccer players in five playing positions during various 4-min small-sided games (SSGs) in comparison to 11-a-side matches revealed that 4 vs. 4 SSGs played with 1 or 2 ball touches increased the high-intensity running and the difficulty to perform technical actions [28]. Small-sided soccer games (SSGs) played on small, medium and large pitches using a high frequency non-differential global positioning system (NdGPS) showed that the small pitch imposed a greater technical demand on players (more passes, shots and tackles) compared to medium and large pitches, and also changes in pitch size impact both the physical and technical demands of SSGs [29]. The investigation of position-specific evolution of physical and technical performance parameters in the English Premier League (EPL) demonstrates those physical demands of wide players and the technical requirements of central players [30]. Moreover, when Silva et al. [31] noticed that tactical behaviors in small-sided and conditioned games (SSCGs) are constrained by field size and skill level; confirm the concept of DCASBs which shows clearly that tactical skills are developed far of the balloon to manage physical and technical abilities nearer to the balloon. By analogy to the new concept of DCASBs, some activities are now managed on the basis of concentric circles like data availability [32], urban activities impacts [33,34], waste risk management [35], security management [36] and decision making [37]. In particular, in football decisions being driven by fan and media pressure rather than in realistic hope of improving the position of the club decisions [38].

V. CONCLUSION

TRIZ is not only a methodology; rather it is also a toolset and knowledge-based technology for analysis and problem solving. It opens up broader prospects of technological application and helps solution seekers methodically. This study examined the use of TRIZ method on creative design of DCASBs. This concept which defines the required abilities of the players to be continuously involved in collective game constitutes a good way for the player's tactical skills evaluation and analysis of soccer game. This concept which is the third inventive finding throughout the history of soccer after the offside rule and systems of play, could be a tool to human resources management for planning, organizing directing and controlling of the human activities to the end that individual tasks are executed. TRIZ does not give directly an applicable solution but it allows generating a different worthy approach in controlling soccer games. Consequently, the last step requires the creativity of the coaches to transform the proposed design of DCASBs to an operational solution for training of players and analyzing the football matches in order to control much more the game.

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