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Two-dimensional probability model-based football games' beneficial incidence orientation judgment research

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ABSTRACT

More and more people keen on football, how to improve shooting success rate troubles broad football lovers. The paper uses probabilities statistics, establishes two-dimensional probability model, judges the most beneficial incidence orientation to provide references for football lovers. Firstly establish space coordinate system in the plane that goal and field locate, it is clear that shooting success rate shows two-dimensional probability distribution. Secondly, analyze each point of field shooting success rate when there is no goalkeeper, and make shooting equivalent success rate curve graph. Analyze shooting success rate in case there is a goalkeeper, establish goalkeeper saving success probability model, combine with goalkeeper saving success rate and shooting success rate in case no goalkeeper, then it can get player shooting success rate in each point of field in case there is a goalkeeper. Use MATLAB software, then it can draw equivalent success rate curve, it is most easily to shoot in the fan shaped area that within 20m nearby the goal, especially for the position in the right ahead of goal.

KEYWORDS

Football shooting;
Incidence orientation;
Probability statistics;
Two-dimensional probability model;
MATLAB software.

INTRODUCTION

Football is a kind of old fitness event, it was originated from Chinese "Chuk-guk" as earliest, and later passed to European by Arabian and developed into current football. Football development up to now, it has already become the most influential sports event in whole world sports events, is called as first main sports in the world. As a competition of whole world concerns, every world cup haunts the heart of several hundred million fans. World famous five main league matches: Bundesliga, La Liga, Premier League, Ligue 1 and Serie A, it surely stirs people's moods when every competition comes across. Football has become all concerned topic at their leisure time. China is a country that owns most fans in the world, it also organizes Chinese football association super league, Chinese football association first division, Chinese football association second division and other league football matches, let people to more keen on football.

Modern football has comprehensiveness, antagonism, integrality and rapidity as well as other features. It not only has big motion difficulty, large physical output, but also has higher requirements on tactics. Football has higher requirements on athlete physical quality level. It not only needs athlete to have fast running speed,

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strong physical endurance, good limbs flexibility, flexible paces, but also requires athlete to have good body gravity center control ability and strength quality in confrontation. In the game process, status changes are intricate that need athlete to have swift thoughts and rapidly observation, judgment and reaction capacity. In football confrontation, it needs fierce competition, and furthermore needs solidarity and cooperation among athletes. Regularly participate in football can improve human body speed, endurance, sensitivity and flexibility so on physical qualities. Promote body's metabolism, improve body's respiratory system, heart and other organs' functions, increase appetite, and improve body absorption capacity. Football game confrontation is fiercely, situation is complex and volatile, which needs athlete to have good attentions, sense and space perception. Long-term participation in football can cultivate positive and progressive spirits, as well as solidarity and cooperation ability. With football development, football becomes more and more "civilian". More and more football fans organize football teams and participate in amateur football team games. However football has big difficulties and high tactics requirements, which causes amateur football teams generally levels to be lower and hard to make progress. Football shooting's method of kicking is diversely and has broad ranges, also suffers interference from goalkeeper when shooting, which furthermore increases football shot difficulties, let football to be "hard to get one score".

Player level high or low mainly reflects in goal and assist success rate. The paper researches from the aspect of goal, improves player football level by improving goal rate. Every football shooting has two cases as goal and fail, different positions' shooting success probabilities are different, in the same position, points that shoot to goal are different, and then shooting success probabilities are also different. When player technical level is fixed, in case no goalkeeper, player shooting position and angle decide shooting success probability, therefore shooting success probabilities are in two-dimensional distribution. The paper discusses from different shooting orientations, makes full-scale analysis of shooting region every point and different shooting directions, finds out most beneficial shooting orientation, helps player to improve shooting success probability and further improve player football level.

MODEL ESTABLISHMENT AND SOLUTION

International standard football field length is 104m, width is 69m; height of goal is 2.44m, width of goal is 7.32m. Regard field and goal respective as two planes. When ball is shot to goal located plane area district, then shooting is successful. Firstly establish space rectangular coordinate system, as Figure 1 show:

As Figure 1 show, plane P is goal located plane Oxz, plane Oxy is field located plane. Angle α is player horizontal direction shooting angle, angle β is ball incident angle when shooting vertically, angle θ is football incident drift angle.

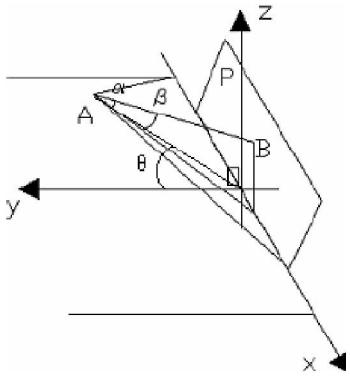

Figure 1 : Shooting orientation schematic diagram

Assume that player every time shooting technical level is fixed, then player every orientation shooting success probability is unchangeable. Player shooting position decides shooting difficulty extent, position that ball is shot to goal located plane decides whether goal or not. Therefore, it can divide shooting success rate into horizontal and vertical two directions.

Player's different positions' shooting success probabilities will show a fixed probability distribution. When player shoots the ball in the dead center, according to experiences, it is clear when player faces to goal and make vertical incidence with 90° angle, it is most easily to shoot in, and success probability becomes higher; football incidence direction and goal located included angle gets smaller, it is more difficult to shoot in, and success probability gets lower. It is clear that horizontal probability shows normal distribution. When player stands at the same position and shoots, the ball gets closer to goal dead center and it will be more easily to shoot in. By analyzing, it is clear that vertical direction shooting success probability shows normal distribution.

Then football shooting success probability shows two-dimensional normal distribution in target plane P.

In case no goalkeeper

Assume that one player basic quality is k, shooting position is horizontal plane Oxy point $A(x_0, y_0)$, distance between it and goal is d, ball shoots in goal located plane P point is $B(y_1, z_1)$. Random variable y, z is mutually independent. Ball dropping into goal located probability is shooting success probability. Assume goal located plan district is D, then shooting success probability is

$$f(y,z)=\frac{1}{2\pi\sigma^2}\exp\left\{-\frac{(y-y_1)^2+(z-z_1)^2}{2\sigma^2}\right\},(y,z)\in D \quad (1)$$

Among them, variance σ and player quality k are in inversely proportion, and is in inversely proportional to d, drift angle θ gets bigger, variance σ gets smaller. Make geometrical analysis of graph, and can get:

$$\cot\theta=\frac{|y_1-y_0|}{x_0} \quad (2)$$

$$d=\sqrt{x_0^2+(y_1-y_0)^2+z_2^1} \quad (3)$$

When ball directly faces to goal center, that is $\theta=\frac{\pi}{2}$, is just related to k, d. Therefore, it can define:

$$\sigma=\frac{d}{k}(\cot\theta+1) \quad (4)$$

Ball dropping point is surely in the ground that $z\geq 0$. Assume that goal plane district is P, in order to balance formula (1) density function, let:

$$\begin{cases}P_p(x_0,y_0,y_1,z_1)=\iint_P f(y,z)dydz\\ P_D(x_0,y_0,y_1,z_1)=\iint_D f(y,z)dydz\end{cases} \quad (5)$$

Take the two ratio then it can get player's field different positions' shooting goal probability:

$$P(x_0,y_0;y_1,z_1)=\frac{P_p(x_0,y_0;y_1,z_1)}{P_D(x_0,y_0;y_1,z_1)} \quad (6)$$

To solve shooting success probability, it should also consider player shooting position. Then player in field position $A(x_0, y_0)$ shooting success probability is:

$$D(x_0,y_0)=\iint_P P(x_0,y_0;y_1,z_1)dy_1dz_1 \quad (7)$$

Field any point coordinate is (x, y). Then by formula (6) and formula (7), it can get player any point shooting success probability in football is:

$$D(x,y)=\iint_P P(x,y;y_1,z_1)dy_1dz_1 \quad (8)$$

By formula (6), it can get:

$$P(x,y;y_1,z_1)=\frac{P_p(x,y;y_1,z_1)}{P_D(x,y;y_1,z_1)} \quad (9)$$

According to formula (3), it can get:

$$d=\sqrt{x^2+(y_1-y)^2+z_2^1} \quad (10)$$

According to formula (2):

$$\cot\theta=\frac{|y_1-y|}{x} \quad (11)$$

Here, it needs firstly to define player basic quality k value. Considering that amateur athlete familiar degree with football is higher than common people, while lower than professional athlete. Assume player is in the right ahead of goal, (then $\theta=\frac{\pi}{2}$) is far from goal d=10m, adopts impulsive shooting method to make power shot. Now, standard deviation should be within 1m, which takes $\sigma=1$. Input the value into formula (4), it can get $k=10$. Input field different positions coordinates into formula (8), with the help of MATLAB software and then it can get field each orientation shooting success probability.

Take any party goal and located half football field, as Figure 2 shows, averagely divide the field into 10×5 grids so as to easier record shooting orientation:

In practical situation, player will not shoot in the edge of field or far distance places from goal in the

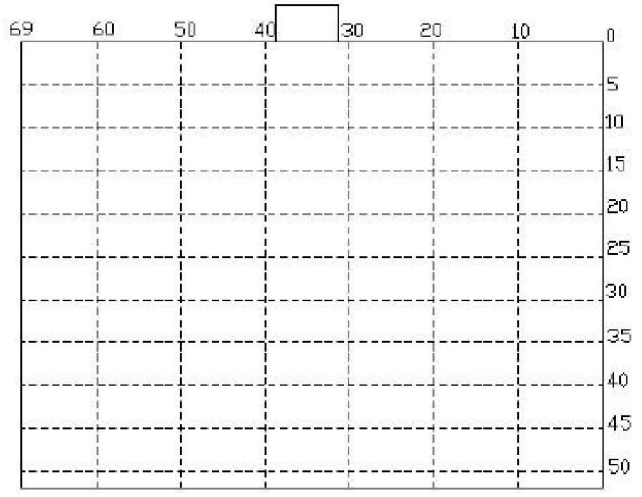

Figure 2 : Football field grid schematic diagram

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TABLE 1: Grid point shooting success rate

—	0.02606	0.05195	0.07750	0.10204	0.12693	0.15026	—
—	0.02778	0.05536	0.08206	0.10918	0.12006	0.16004	—
—	0.02966	0.05910	0.08809	0.11643	0.14392	0.17040	—
—	0.03173	0.06319	0.09417	0.12420	0.15263	0.18169	—
—	0.03399	0.06792	0.10081	0.13304	0.16419	0.19401	—
0	0.03649	0.07265	010811	0.14209	0.17579	0.20748	0
0	0.03927	0.07813	0.11619	0.15312	0.18854	0.22223	0
0	0.04234	0.08420	0.12013	0.16417	0.20207	0.23842	0
—	0.04576	0.09095	0.13505	0.17755	0.21806	0.20621	—
—	0.04958	0.09849	0.14611	0.19182	0.23519	0.27581	—

Note:"—" represents points that can be ignored and no taken into calculation

field. While it selects to shoot near to goal and in the orientation that shooting drift angle is small. According to experience, it is clear that player more shoots in goal nearby fan-shaped districts; therefore it can ignore partial points and simplify calculation. With the help of MATLAB software, calculate and get Figure 1 grid points shooting success rate result as TABLE 1 show.

In calculation process, it finds that in the adjacent two points, shooting success probabilities are nearly the same. And center on goal, in same radius fan-shaped district, shooting success probabilities are nearly the same, which conforms to practical situation. It also shows probability statistical model accuracy, and its applicability in calculating shooting success probability.

Use TABLE 1 data, with the help of MATLAB software, it can draw field different orientations' shooting equivalent success rate curve, as Figure 3 show:

In case there's a goalkeeper

Assume that goalkeeper stands in the middle position of goal. It is most easily for player to successful shoot in the right ahead of goal, and then goalkeeper is most easily to save the ball in the goal central position. Player shoots football from one point in the field to goal located plane, assume football dropping point in the goal is $(x, z) \in P$.

Propose that ball arrives at goal located plane by time t. When ball flies to goal, goalkeeper can roughly estimate ball drop point according to football movement curve, and moves toward football drop point. So time t gets bigger, the goalkeeper will be easier to succeed in saving. Therefore, set goalkeeper saving success probability to be $P_0(t, y, z)$.

When time t is fixed, the ball gets closer to goalkeeper location, and save will be easier done, that ball drop point gets closer to goal central position, it is more likely to succeed. Sois centered on goalkeeper position, diminishing two-dimensional function that radiates around. When time t gradually gets smaller, goalkeeper moving time reduces, it causes ball already enters into goal while goalkeeper hasn't yet arrived at goal edge position. Therefore, function image area gets small.

When time t is fixed, the ball gets closer to goalkeeper location, and save will be easier done, that ball drop point gets closer to goal central position, it is more likely to succeed. So $P_0(t, y, z)$ is centered on goalkeeper position, diminishing two-dimensional function that radiates around. When time t gradually gets smaller, goalkeeper moving time reduces, it causes ball already

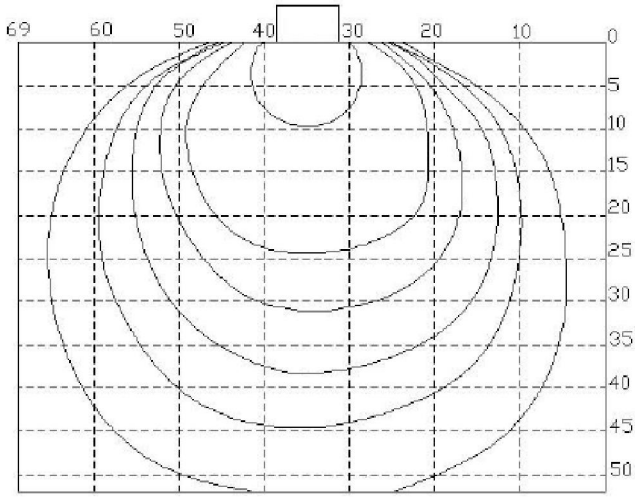

Figure 3 : Equivalent success rate curve graph

enters into goal while goalkeeper hasn't yet arrived at goal edge position. Therefore, function image area gets small.

Considering practical status, goalkeeper doesn't surely stand in the midpoint of goal. Assume when player shoots, goalkeeper's locations deflect goal center position is a. Set goalkeeper reaction time is ct.

Based on above analysis, it can get:

$$\mathbf{P_0(t,y,z) = \exp\left\{-\frac{(y-a)^2+(z-1.25)^2}{ct}\right\}} \quad \mathbf{(12)}$$

Scientific research shows that common people reaction time is 0.12~0.15s. In the famous" scrip experiment ", scientists utilizes formula $s = \frac{1}{2}gt^2$, according to subject group caught scrip position, they get normal people reaction time is nearly $\frac{\sqrt{2}}{10}$ s. Considering it is amateur goalkeeper, reaction time will be lower than professional goalkeeper, and slightly higher than common people. Therefore it can take $c = 1/7$. It can get:

$$\mathbf{a = \frac{7.32\sqrt{(y_0+3.66)^2+x_0^2}}{\sqrt{(y_0+3.66)^2+x_0^2}+\sqrt{(y_0-3.66)^2+x_0^2}} - 3.66} \quad \mathbf{(13)}$$

When goalkeeper succeeds in saving, player fails in shooting. When goalkeeper fails in saving, then player succeeds in shooting. If there is no goalkeeper, player will surely succeed in shooting, then in case there's a goalkeeper, shooting success probability is $1 - P_0(t, y, z)$. Combine with 2.1 research results, it can get player in field any point $A(x_0, y_0)$, shooting success probability is:

$$\mathbf{P_P = (x_0y_0;y_1,z_1) = \int_P f(y,z)[1 - P_0(t,y,z)]dydz} \quad \mathbf{(14)}$$

Therefore, it can get field any point (x, y), player shooting success probability is:

$$\mathbf{D(x,y) = \int_P P(x,y;y_1,z_1)dy_1dz_1} \quad \mathbf{(15)}$$

According research process when no goalkeeper here, it has

$$P(x, y; y_1, z_1) = \frac{P_p(x, y; y_1, z_1)}{P_D(x, y; y_1, z_1)}$$

$$P_D(x_0, y_0, y_1, z_1) = \iint_D f(y, z)dydz$$

Different shooting methods and shooting forces, football flight speeds are different. If shooting force is too big, the goal rate will reduce. And shooting speed is too small, it will increase goalkeeper saving success probability. Therefore, take football flight speed as $v_0 = 10m/s$.

While the distance between ball and goal is d, according to kinematics knowledge, it can get:

$$\mathbf{t = \frac{d}{v_0}} \quad \mathbf{(16)}$$

Combine with the case there is no goalkeeper, player shooting success probability research results. Input relative formula and data into formula (15), with the help of MATLAB software, it solves player shooting success probability in different orientation of field in case there is a goalkeeper. Partial orientation result is as TABLE 2 show:

Observe above data, it can find that no matter in any orientation, in case there is a goalkeeper, player shooting success probability is less than in case no goalkeeper. It conforms to practical status.

According to TABLE 2 data, with the help of MATLAB software, it can make field different orientations' shooting equivalent success rate curve in case

TABLE 2 : Shooting success probability in case there is a goalkeeper

—	**0.000307**	**0.000613**	**0.000917**	**0.001219**	**0.001516**	**0.001807**	—
—	0.000357	0.000713	0.001067	0.001417	0.001762	0.002099	—
—	0.000417	0.000833	0.001246	0.001655	0.002056	0.002449	—
—	0.000490	0.000978	0.001462	0.001490	0.002411	0.002868	—
—	0.000578	0.001153	0.001724	0.002286	0.002838	0.003375	—
0	0.000816	0.001366	0.002042	0.002707	0.003358	0.003989	0
0	0.000816	0.001628	0.002431	0.003222	0.003993	0.004739	0
0	0.000978	0.001950	0.002912	0.003856	0.004775	0.005660	0
—	0.001179	0.002351	0.003508	0.004642	0.005742	0.006789	—
—	0.001432	0.002852	0.004204	0.005632	0.006948	0.008212	—

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there is a goalkeeper, as Figure 4 show:

By Figure 4, it is clear that when there is a goalkeeper; shooting success district is obvious diminishing. And the place gets closer to goal, especial for the position directly faces to goal; it is more likely to succeed in shooting. It conforms to practical situation, and meanwhile it also shows field region distribution rationality.

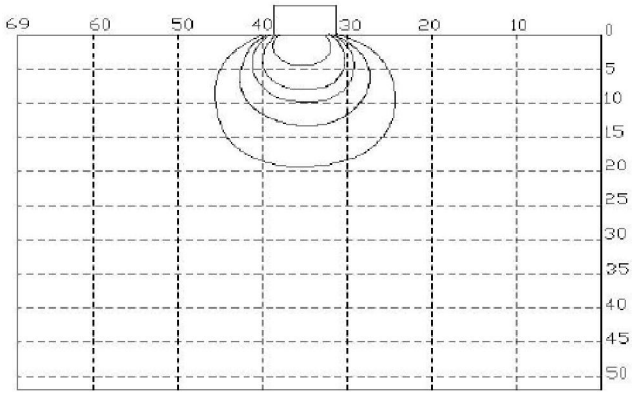

Figure 4 : Equivalent success rate curve graph in case there is a goalkeeper

CONCLUSIONS

When there is a goalkeeper to defend, shooting success rate is obviously diminishing, equivalent success rate range diminishes. However, big shooting success rate place is still nearby goal, especially for goal's dead ahead. When there is a goalkeeper, most easily goal places distribute in the fan shaped area that within 20m nearby the goal, and the position in the right ahead of goal is most likely to succeed in shooting.

The paper obtained player quality is a constant, but in practical situation, player quality is different. If player quality gets higher, then when k increases, shooting success rate will increase. Now player can select to shoot in further distance according to competition status in the field. And in football game, it not only has goalkeeper to block shooting, but also will be hindered by opponents. And players' cooperation and mutual assistance is also very important. Therefore, in game, it also needs to make concrete analysis of field status and select proper shooting position.

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