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Genetic algorithms model study based on best throwing parameter of shot

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ABSTRACT

This paper uses the theory of mechanics and mathematical software, studies the farthest horizontal distance of the shot throwing. It uses genetic algorithm to obtain the best parameters during the throwing process, and conducts sensitivity analysis on the influencing factors in the shot throwing process, determines the primary and secondary relationships between the factors. Then on this basis, it discusses the factors affecting the farthest horizontal distance of throwing, establishes the farthest throwing models; the athlete can calculate the best throwing angle according to the height and throwing habit. It tests the model by taking world-class Shot athletes Randy Barnes as an example.

KEYWORDS

Throwing angle;
Throwing speed;
Throwing model;
Genetic algorithm.

INTRODUCTION

Shot put is one of the athletics throwing event, it has an extremity significant to enhance physique, especially to develop the strength of the trunk, upper and lower limbs. It appeared in Britain in the 19th century. Shortly athletes from other countries also began practicing shot put. In 1896 the first Olympic Games took men's Shot put as an official event, and the results were 11.22m. In 1948 the tenth Olympic took women's shot put as an official event, and the results are 13.75m.

Athletics sports develop scientifically, and the throwing techniques of shot put are constantly improving. Coaches and athletes start from the most important factor that determines the results, reform technology, change the oldest method of lunge ball pushing into the side sliding ball pushing, in the early 1950s the ball pushing from the side develops into ball pushing from the side. During the development process of back throwing technology, the rotation method of ball pushing appeared. This way completely changes the nature of the ball pushing from the back in a sense, changes the linear motion to the combination of rotary and linear motion.

This article aims to get the farthest throwing model by studying the influencing factors of shot throwing, applies this equation to the specific case of athletes, in the case that athlete's height and weight are determined, analyzes the impact of throwing velocity and throwing angle on the throwing distance, and it has some significance for the improvement of the athletes' performance.

GENETIC ALGORITHMS ANALYSIS OF SHOT THROWING PROCESS

Genetic algorithms is consistent with the traditional optimization algorithm on the idea and applications, but the objective function of genetic algorithm uses only the fitness function, does not use derivatives or other auxil-

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iary information. Therefore, genetic algorithm has a stronger adaptive capacity for the problem. The iterative process of genetic algorithms in the calculation includes the encoding, selection, and crossover and mutation process. Crossover and sudden mutation maintain the diversity of the search space, potentially has the ability to adapt to the environmental change; genetic algorithm simultaneously search many points in space through evaluation and elimination process, and can fully search, thus it can quickly global convergence.

The encoding process of genetic algorithm uses mathematical coding, the crossover process encodes by formula (1) and formula (2), the mutation process encodes according to formula (3):

$$X_1 = X_1 + (1-\lambda)X_2 \quad (1)$$

$$X_2 = X_2 + (1-\lambda)X_1 \quad (2)$$

$$\Delta(t,y) = y \cdot r(1-\frac{t}{T})^b \quad (3)$$

Wherein $\lambda \in (0,1)$ t is the number of iterations, T is the termination of algebra and $b > 0$.

In the iteration calculation process, the crossover probability is $P_c = 0.3$, the mutation probability is $P_m = 0.1$ $\lambda = 0.5$, the termination algebra is $T = 1000$, and the population size is $N = 10$ $b = 1.5$. This paper takes the international women's 4kg shot put competition for example, obtains the results shown in TABLE 1.

After throwing out the Shot is a ramp throwing motion process; As can be seen from the results in above TABLE 1, under preconditions of certain best shot angle, shot time is the process of accumulation and sudden release of human biological energy; and this time is too short, energy cannot be accumulated, the sudden release of energy cannot make this time long.

Then this paper conducts sensitivity analysis on the influencing factors in the process of Shot Put, determines the primary and secondary relationship between the factors. Sensitivity analysis is the size of the impact on the throwing distance when each factors changes. Factors with big influence are called sensitive, otherwise it is known as insensitive. The model has five factors (shot angle, shot height, shot power, the time period from beginning to push the shot to shooting out and the shot speed); due to the difficulty of sensitivity analysis by using analytical methods, so when these five factors change within their respective constraints, the change range of the throwing distance can be calculated by numerical method. By comparing the size of the difference, determine the importance of each factor on the throwing distance.

Shot time usually depends on the conversion time length of the muscle from the conceded contraction to the restraint contraction, subjects to the constraints of the transmission and transformation rule between human internal kinetic and the potential energy of muscle elasticity and other internal reasons.

By comparing the average range, in the remaining four factors, shot speed is the most important external factors affecting throwing distance, followed by shot height. Although the variation range of the throwing distance caused by the changes of the shot angle is greater than the shot height, the tolerance limit of the best shot angle is greater, i.e., when the projection angle is within a certain range, the effect on the throwing distance is small; although the adjustment of the best shot angle is important to the stability of the throwing distances, but it does not need to be too accurate. In practice, different athletes should determine the best throwing angle suitable for him according to their specific circumstances.

THE FARTHEST THROWING MODEL

Modeling

This article simplifies the throwing process of athletes as shown in Figure 1 below.

The maximum throwing height h of shot put

TABLE 1: Relevant parameters of shot

Name	Shot angle	Shot height	Shot force	Shot time	Speed
Value ranges of independent variable	0-46	1.8-2.15	0-226	0-0.25	0-2.3
Values of independent variable	35.77	2.1	225	0.24	2
Shot speed			14.09		
Throwing distance			21.78		

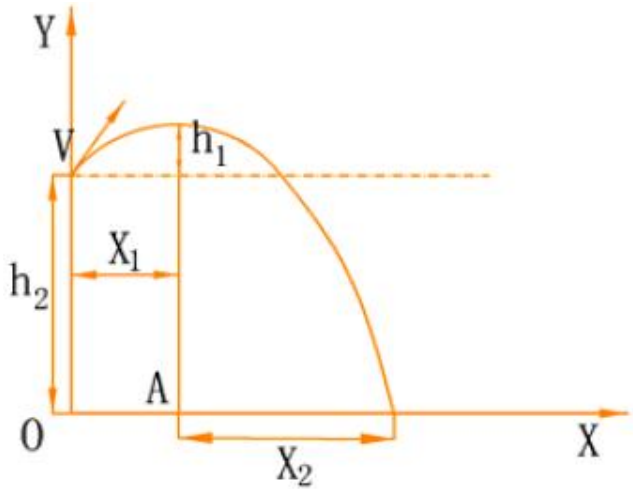

Figure 1 : The simulation of Shot throwing

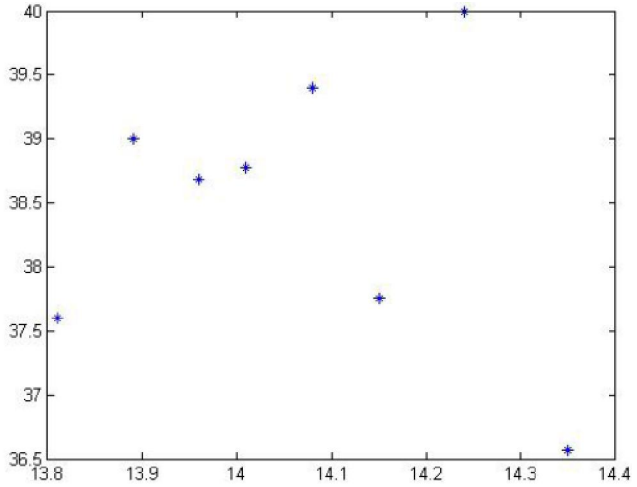

Figure 2 : Scatter diagram

is $h = h_1 + h_2 = \frac{1}{2}gt^2$, the flight time t of shot put is $t = \frac{v\sin\theta}{g}$, the total flight distance s of the shot is:

$$s = x_1 + x_2$$
$$x_1 = v\cos\theta * t_1$$
$$x_2 = v\cos\theta * t_2$$

Namely $s = \frac{v^2\sin 2\theta}{2g} + \sqrt{(\frac{v^2\sin 2\theta}{g}) + (\frac{v^2\cos^2\theta}{g})}$

When the throwing distance is the maximum, we have the following relationship:

$$\cos 2\theta = \frac{g}{g + v^2/h}$$

Wherein $0 < 2\theta < 90^0$, $\cos 2\theta$ has a monotonously increasing trend in the domain of definition, we have:

(1) Height is constant, throwing angle and throwing velocity is positively correlated

(2) The throwing velocity is constant, throwing angle and throwing height is negatively correlated

Then throwing angle formula the farthest throwing distance is $\cos 2\theta = \frac{g}{g + v^2/h}$.

TABLE 2 : Throwing Shot data

Order	Throwing speed m/s	Throwing angle	Measured results
1	13.81	37.6	20.95
2	13.96	38.69	21.34
3	14.01	38.78	21.24
4	14.15	37.75	22.54
5	13.89	39	21.41
6	14.35	36.57	22.85
7	14.24	40	22.45
8	14.08	39.4	22.01

Model application

According to the above model, apply it into the shot put of world-class athlete Randy Barnes (with height of 1.94m and weight of 137kg); assuming that his initial throwing velocity is generally 13.8-14.5m/s. Measured results are between 20m-23m (, the maximum distance of the world record holder is 23.12m) and the data is shown in TABLE 2.

According to TABLE 2, take the initial throwing velocity as the variable and fit out the equation on the throwing angle, and draw a scatter plot of the throwing velocity and throwing angle, the procedures and results are as follows:

The scatter diagram code (results are shown in Figure 2):

```
p=[13.81;13.96;14.01;14.15;13.89;14.35;14.24;14.08;];
u=[37.6;38.69;38.78;37.75;39;36.57;40;39.4;];
plot(p,u,'*'); A=polyfit(p,u,3);
a=A(1),b=A(2),c=A(3),d=A(4);p1=13:0.1:15,
u1=polyval(A,p1);
plot(p1,u1,p,u,'o')
```

The fitting diagram code (results are shown in Figure 3):

```
p=[13.81;13.96;14.01;14.15;13.89;14.35;14.24;14.08;];
u=[37.6;38.69;38.78;37.75;39;36.57;40;39.4;];
```

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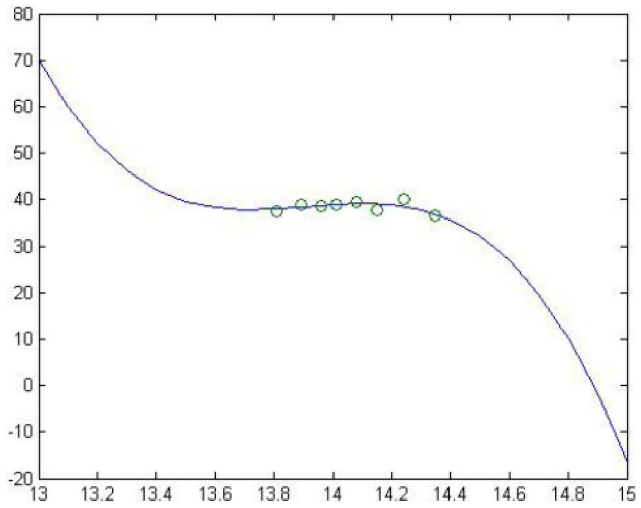

Figure 3 : Figure of the fitting equation

```
A=polyfit(p,u,3);
a=A(1),b=A(2),c=A(3),d=A(4);
p1=13:0.1:15;
u1=polyval(A,p1);
plot(p1,u1,p,u,'o')
```

Get the fitting equation y=-47.7794*x^3+1994.6*x^2 +-27749*x+130000

According to the function formula of throwing velocity and throwing distance and throwing height, because the throwing height differs little, the impact on the performance is not outstanding, so it is set as a fixed value. Assuming the throwing height is 2.01m, set this value as the constant value, you can get the corresponding relation between throwing speed and throwing angle.

TABLE 3 shows that the throwing distance and throwing velocity is positively correlated; when the distance is the maximum, the throwing speed is 14.00m / s, the throwing angle is 37.27 degrees, at this time Barnes get the best results throwing the shot.

TABLE 3 : Throwing speed and throwing angle

Throwing speed	13.50	13.60	13.70	13.80	13.90	14.00	14.10	14.20	14.30	14.40	14.50
Throwing distance	21.32	21.63	21.94	22.22	22.47	22.62	22.56	22.05	20.72	18.11	14.03
Throwing angle	38.05	38.50	38.92	39.04	38.58	37.27	34.85	31.06	25.64	18.36	8.97

CONCLUSIONS

The model combines the instance of shot put champion Barnes, conducts a detailed study of the specific impact of the throwing speed, throwing angle and throwing height on throwing distance, and by quantitative calculation, obtains the best throwing angles for Barnes, and how to throw in the training process should be throwing, and provides a reasonable and efficient reference to Barnes. Different people should choose different training modes, so players should choose their own ways to improve the throwing performance.

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