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The Best Angle of 3-point shoots Based on Stephen Curry

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Introduction

The NBA, short for the National Basketball Association, is a professional men's basketball league based in North America. When we watching the players shoot in game, we know that sometimes they make small error but still make the basket. It seems reasonable for them to shoot go in depends on the initial angle that the ball was thrown. We'll find the best shooting angle for Curry in this model.

Applications

1. Defensive Blocking: By calculating the angle of the ball and the trajectoryof the parabola, it is possible to figure out how high a defender would have to jump to successfully complete a block
2. Hawk-eye Technology: It's a sophisticated system used in sports to track the trajectory of balls and is mentioned in the context of basketball performance analysis [1]

1 Approaches

[2] We'll do this by taking standard projectile motion equations that are derived from Newton's second law of motion. We start by resolving the initial velocity v_0 into horizontal and vertical line:

$$v_H = v_0 cos(\theta_0)$$

$$u_V = v_0 sin(\theta_0)$$

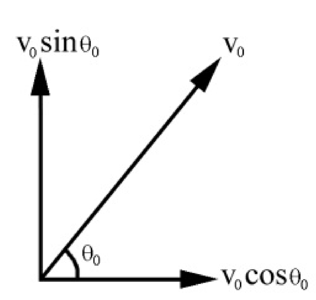

Figure 1: an important plot

and then we find the horizontal distance($x(t)$ = vt),we have:

$$l = x(t) = v_0 cos(\theta_0) t$$

and the vertical distance of motion is given by:

$$h = y(t) = vt + \frac{1}{2} g t^2 = v_0 sin(\theta_0) + \frac{1}{2} g t^2$$

where h is the vertical distance to the center of basket.
we now need to find the t :

$$t = \frac{l}{v_0 cos(\theta_0)}$$

after substitution, we find the initial velocity v_0 that we needed,so that the ball goes though the middle of the hoop:

$$v_0 = \frac{l}{cos(\theta_0)} \sqrt{\frac{-g}{2(l tan(\theta_0) - h)}}$$

After that, we have 2 criteria for the ball still goes in the net :

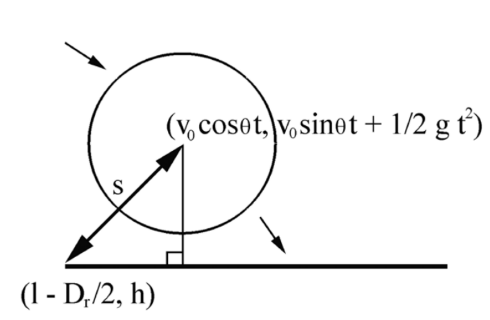

Figure 2: Graphically analyze two criteria

$$s^2 = (x(t) - (l - D_r/2)^2 + ((y(t) - h)^2 > (D_b/2)^2)$$

$$where \frac{l - D_r}{v_0 cos(\theta_0^{oops})} \le t \le \frac{1}{-g(v_0 sin(\theta_0^{oops}) + \sqrt{v_0{}^2 sin^2(\theta_0^{oops}) + 2gh})}$$

$$x + D_b/2 = l + D_r/2$$

Thus,we have:

$$s^2 - (D_b/2)^2 = 0 \, and \, x - l + \frac{D_b - D_r}{2} = 0$$

[3]
For solving for θ_{low} and θ_{high} we find the minimum deviation from θ_0, we obtain:

$$e(\theta_0) = min(\theta_{high} - \theta_0, \theta_0 - \theta_{low})$$

After using Matlab ,we obtain the numerical solution:

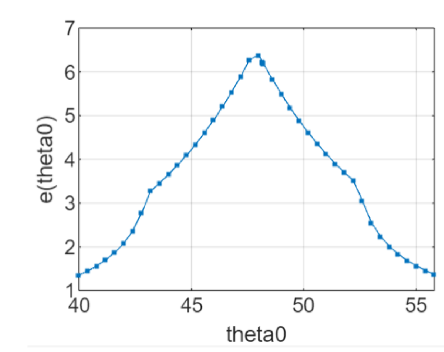

Figure 3: With discretization

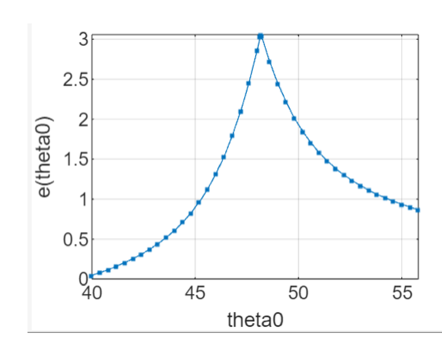

Figure 4: Without discretization

Type	Best angle	Maximum error
Without Discretiztion	48.18	3.06
Discretiztion	48.00	6.38

Table 1: Best angle and error prediction

2 Conclusions || Discussion

- Limitations: The model does not consider the air resistance, that's a big factor to affect the angle and trajectory of shooting. Next, we do not consider about the optimal trajectory of the ball.
- Improvements: Define two parts about finding the best trajectory and adding the air resistance. Also we can do the classification for each entity and implemented new and more difficult algorithms to do such an analysis

References

[1] S. Angeles, "Analyzing Basketball Free Throw Trajectory Using Vector Kinematics ," 09 2022. [Online]. Available: https://www.researchgate.net/publication/363413269

[2] J. M. Gablonsky and A. S. I. D. Lang, "Modeling basketball free throws," *SIAM review*, vol. 47, no. 4, pp. 775–798, 1 2005. [Online]. Available: https://doi.org/10.1137/s0036144598339555

[3] R. Raj-Prasad, J. Joseph, B. Jin, and Y. S. Chen, "Dynamic Analysis and Optimization of Steph Curry's 3-point shot," Tech. Rep., 1 2016. [Online]. Available: https://search.datacite.org/works/10.13140/RG.2.2.35452.13445