Bowling Simulations Inform Strike Strategy

A physics-based model that captures the complex dynamics of tenpin bowling could help players to increase their chances of scoring a strike.

By **Susan Curtis**

For most of us, knocking down all 10 bowling pins at once to score the perfect strike is an occasional triumph that owes more to luck than judgement. But even elite players must contend with a complex combination of variables that affect the outcome of their shots, ranging from the way they deliver the ball to the specific lane conditions at different venues and tournaments. Help is at hand, however. A team of physicists from the US and the UK has introduced a comprehensive model that predicts the behavior of a bowling bowl to identify the optimal launch position and trajectory for scoring a strike [**1**].

"The model can provide bowlers and coaches with a visual guide that shows how the ball path will change if particular features of the shot are changed, such as the speed, the angular velocity, or the axis of rotation," says team member Curtis Hooper, a researcher at Loughborough University in the UK, who is also a national coach for Team England.

Modeling the trajectory of a bowling bowl could help professional players to optimize their strategy for a specific tournament.
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With so many factors at play, most previous attempts to improve the chances of scoring a strike have taken a statistical approach that analyzes the prior performance of professional bowlers. These studies have indicated, for example, that players should aim to hit the headpin at an angle of around 6° and an offset of 6 cm from the center. Some mathematical models have also studied one key feature of bowling balls, which is that their internal structure includes a solid weight block that modifies their center of gravity and rotational characteristics. This structure changes the axis of rotation, which in turn contributes to the ball's parabolic motion.

In their new work Hooper and colleagues have developed a more sophisticated model that accounts for other key factors that affect the trajectory of the ball, such as the friction between the ball's surface and the bowling lane. Starting with the classical equations of motion for a sphere rolling on a surface, they derived a coupled system of six differential equations that predicts the outcome of a shot from a set of initial conditions that can be tailored to the bowling characteristics of a particular player. These starting conditions include the distribution of mass within the ball, as well as its speed, direction, and angular velocity at the point of release.

Using real-life data from competitive bowlers to set the initial conditions, the researchers used the model to simulate the effect that variations in friction have on the shot trajectory. Tournament organizers often alter the friction profile along the lane—either to challenge the precision of the competitors or to encourage higher scores—which is achieved by applying oil to different areas of the polished wooden surface. To create a “short” pattern, for example, oil is applied in varying amounts within the first 13 m of a standard 18.3-m bowling lane. In this scenario the model predicts that the chance of a strike reaches a maximum of 89% when a player delivers the ball at an angle of 1.8° and at a lateral offset equivalent to the 28th board from the edge out of the 39 that makes up a standard bowling lane.

Knowing that ideal trajectory might help players to optimize their shots, but even the best bowlers do not always release the ball exactly as they intend. Small inaccuracies in the launch angle can alter the position of the ball by several centimeters once it reaches the pins, and so the researchers modeled the range of possible paths when the launch angle changes by up to 0.15° in either direction, left or right. When the ball is delivered along the ideal trajectory for the short pattern, the simulations show that these small variations deflect the ball only by a couple of centimeters. When a less ideal trajectory is chosen, however, the final position of the ball can change by up to 8 cm.

Hooper and colleagues say that their model will provide a useful tool for players and their coaches to optimize their game strategy for each tournament. “Models like this can run numerous ‘what-if’ scenarios to work out the best way to get a strike,” says Steve Haake, a professor in sports engineering at Sheffield Hallam University in the UK, who was not involved in the current work. “This paper takes a nice approach, creating models that make sense from a player’s point of view.”

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REFERENCES

1. S. S. M. Ji *et al.*, “Using physics simulations to find targeting strategies in competitive tenpin bowling,” **AIP Adv. 15 (2025).**