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Improve the Batting Skills of Cricketers for Fast Pitch Conditions Through an Innovative Ball Projecting Platform

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ABSTRACT: In cricket, ball pitching conditions vary depending on different geological locations in the world. These geological conditions mainly affect pace, bounce, and the seam of the ball. For example, Indian subcontinent pitches have a slower pace and bounce than the other locations in the world. They are known as slow pitches. Australia, England, and even South African pitches have much speed, bounce, and do not deteriorate much with time. Asian batsmen struggle with decision-making and stroke selection in these fast-bouncy pitches; more often, the weight transfer between the front and back feet is vulnerable to pace bowlers. They find it difficult to adapt quickly to these pitch conditions because they are not familiar with fast, bouncy pitches; even top-class batsmen get dismissed due to poor shot selection. Sri Lanka and most asian countries try to build fast-pitches in their homelands to be familiar with higher pace, seam, and bouncy conditions. As a solution, this study focused on developing a versatile platform to replicate the fast pitches' seaming and bouncing conditions. In this research, a rotatable platform controlled via an Arduino interface is assembled to manipulate different angles to induce the seaming effect. After a systematical analysis, it can be shown that the possible enhancement of bounce that arises from the right length (5 m – 6 m) by employing the developed platform. Also, it is observed that using real-time footages that batsmen who are practicing utilizing this platform are trying to adapt to such different conditions by controlling weight transfer since the implemented platform can be used to adjust the fast-pitch conditions regarding obtained testing results.

Keywords: Arduino, Batting Practice, Bounce, Fast pitches, Pace, Rotatable platform, Slow pitches.

I. INTRODUCTION

Cricket is a popular game in several countries, mostly in Indian sub-continent. Cricket has nearly a history of two centuries, as the first international game was played between the United States vs Canada, in September 1844 in Bloomingdale Park, Manhattan [1]. Cricket was mostly a gentlemen's game in the English high society. However, in the 21st-century cricket has become more prevalent in many countries all around the world. In 2020, there are 10 test cricket playing nations representing five continents of the world [2]. Four countries among them are sub-continent countries (India, Pakistan, Sri Lanka and Bangladesh). Cricket is the most popular sport in these sub-continent countries, comparing with other test playing nations. Also, the highest number of spectators can be identified among these countries. In cricket, players mainly engage in batting, bowling and fielding. The geographical and weather factors are affecting as an advantage or disadvantage in these playing styles. Since both the weather and geographical factors primarily affect to a cricket match. This effect can be identified easily during cricket matches since most of the times, the touring team practice hard to adapt to the home team environment. Furthermore, they have to select players who can adapt to the environment in these venues.

A cricket pitch acts a significant role in a cricket match. The cricket pitch is the rectangular area in the middle, known as the pitch that is 20.12 m by 3.04 m wide [3] Which is the area that ball is bowled. Following terms are used to describe the pitch conditions.

– Pace
– Bounce

– Spin
– Consistency
– Deterioration

'Pace' describes as to how fast delivery will come at batsman after bouncing.

'Bounce' describes the steepness of the path of delivery after pitching.

'Spin' describes the affinity of delivery to undergo lateral movement after bouncing due to the rotational motion of the ball.

'Consistency' describes the variation of the above factors of the pitch with the time.

'Deterioration' describes the length of time; a pitch is likely to maintain a certain level of 'Pace' and 'Bounce' [4].

The qualities mentioned above change with the venue. There are several marginal differences can be identified when comparing the sub-continent pitches with other venues at England, Australia and South Africa. Mainly these pitches are categorized as 'Fast' and 'Slow' pitches. 'Fast' pitches commonly are 'Bouncy' pitches, as well as 'Slow' pitches, are identified as ‘Low’ pitches. Most of the subcontinent pitches are slow and low [5]. Since Asian batsmen are struggling to maintain their natural performance in non-Asian venues, it is hard to go for their natural strokes due to the different 'Bounce', 'Pace' and 'Seam' conditions. Most of the batsmen try to select the strokes that are familiar with Asian conditions. However, this shot selection is not useful to survive against higher, bounce and pace in fast pitches. Since there should be an effective practicing method to adapt to fast-pitch conditions creating an automated ball projecting platform that can demonstrate a higher pace, higher bounce and a required seam, that does not depend on the geographical conditions of the practicing location.

Furthermore, it is facilitated with mechatronic instruments that help to make different seaming conditions as required for the practicing sessions. This research focuses on the 'good length' pitch area, which is considered as hard to play by the batsman.

From the bowler's point of view, the ideal length of delivery in terms of the difficulty it poses for the batsman, who must quickly decide whether to playback foot or forward foot [6]. For much more useful results, the automated platform was tested only for good length balls.

II. MATERIALS AND METHODS

The whole system consists of four springs parallelly (two springs for the steel plate support and the other two for angling the plate). The reason for using springs is to create the bouncing conditions to the ball. The platform was designed by using a steel plate that is strong enough to bear the impact by the leather ball when pitching with high speeds [7] and can recreate the bounce and pace that can be experienced in the Australian and England pitches [8]. Two steel shafts were balanced and fixed on both sides along the tilting axis to distribute the steel plate's weight. The steel plate also needs to be tilted a few degrees clockwise and anticlockwise to create the ball's seaming conditions on both sides. Two mechanical screw jacks are used for the tilting mechanism by fixing both sides of the steel plate, which work oppositely one another, i.e., if one jack moves downward direction, the other jack moves upward direction. Ball projecting platform consists of four main parts. They are,

A. Steel plate mechanism with shaft
B. Steel plate holding mechanism
C. Scissor jack mechanism
D. Open-loop control system

A. Steel plate mechanism with shaft

The steel plate mechanism consists of a steel plate of 40 kg of weight 1 m length, 1 m width, and 5 mm thickness, two steel shafts with 25mm of diameter and 225 mm of length, and four brackets fabricated according to the shape of the shaft which can be fixed to the steel plate along the tilting axis. The brackets were permanently joined (welded) to the steel plate from the bottom side along the tilting axis. Then the shafts were assembled, which steel plate can rotate freely relative to it in both directions. The surface of the shafts and brackets were smoothly finished and lubricated to reduce friction. Friction can occur because of the metal-to-metal contact when rotating.

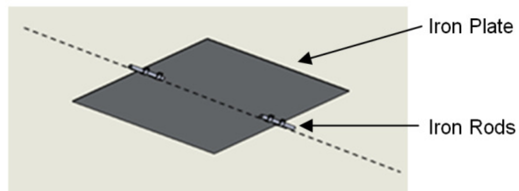

Fig. 1. Steel Plate with the support of shafts.

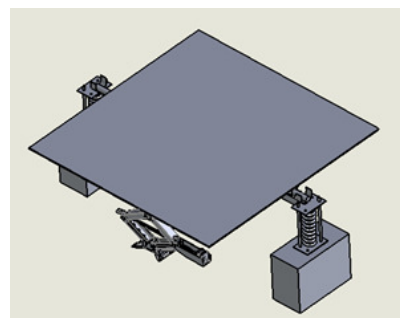

Fig. 2. Ball Projecting Platform.

B. Steel plate holding mechanism

In the design, two parts of this mechanism were assembled from both ends. This mechanism is designed to hold the steel plate from its connected shafts while allowing the shaft to rotate freely on the curved plate and create the bouncing conditions by allowing the springs to move in a vertical direction. The springs with a spring constant of $k = 1.25 \times 104\ N\ m^{-1}$, permanently joined with two steel plates from the top and the bottom sides to distribute the force in a small area without creating any critical points which lead to failures when using a long period and to fix guided rods which restrict the uneven movements of the spring and allow only to move in the vertical direction. To create the optimum height of the screw jack, a wooden log of 300 mm length, 150 mm width, and 200 mm of height was used below the spring, which connects to the ground level.

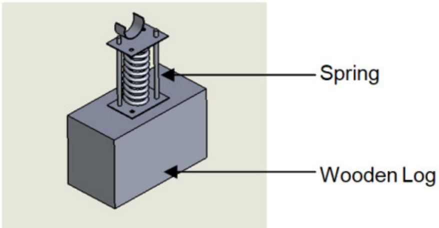

Fig. 3. Steel plate holding mechanism.

C. Scissor jack mechanism

In the final design, two of the above screw jack (7 kN) assemblies were used under the steel plate on both the left and right sides of the tilting axis. The scissor jack mechanism was used to tilt the steel along the plate's tilting axis to create the seam of the ball. The screw jack [9] uses the screw mechanism to get its power. As the screw section is turned clockwise direction, two ends of the screw jack move closer each together, and the gears of the screw are pushing up the arms. Also, the amount of force being applied is multiplied. In this design, the stepper motor coupled to one end of the screw shaft, and a unique rail was designed to hold the motor body without moving with the screw. A spring was placed between steel plates on the top of the screw jack to keep the bouncing conditions without any disturbance by the platform's rigid fixings.

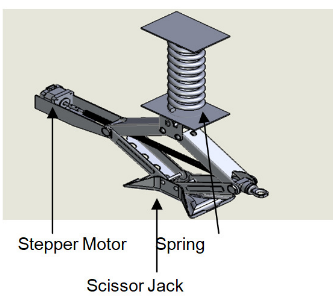

Fig. 4. Scissor jacks with spring support.

D. The open-loop control system

The open-loop control system is used for controlling the seaming property of the ball remotely. This method helps the batting coach correctly adjust the ball's seaming during the practice sessions, merely using his mobile phone. This system consists of two NEMA-17 stepper motors, L293D motor shield, Arduino MEGA 2560 microcontroller, HC-05 Bluetooth module, and mobile application.

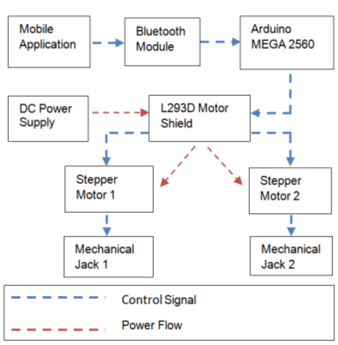

Fig. 5 Open Loop Control System

For the simplicity of the operation, three pre-defined values are stored in the mobile application; these three values represent different iron plates' angles. The user can switch between these values for the required adjustment of the pitch. Also, Arduino 2560 microcontroller can be programmed with a looped algorithm for fully automatic operation. This method helps to continue a practice session by the player, using this platform and a ball feeding machine.

A Stepper motor is a particular type of DC motor. Stepper motor can rotate in steps. There are multiple coils in the stator of the motor. By energizing these coils stepwise, the motor can achieve a step motion. Therefore, the number of steps and rotating speed can be organized in a computerized method. Since the stepper motor is used for more precise control, NEMA 17 stepper motor [10] is used for rotating the Iron plate in this project.

Model No. : 17HS1352-P4130,
Holding torque: 3.2 kg.cm, Step angle: 1.8°

Fig. 6. NEMA 17 Stepper Motor.

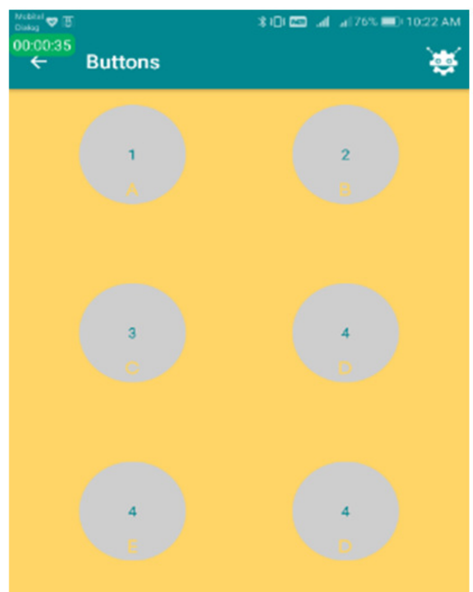

Fig. 7. Bluetooth Mobile Application.

In this Arduino program, the rotation speed is set to 30 rpm. Two stepper motors are parallelly controlled, but with different rotating directions (clockwise and anticlockwise). This method helps to uplift one scissor jack, while another is down lifting. Additionally, a 10 x 10 grid was used to measure the effect to the ball impact position after bounce as given in Fig. 8.

	A	B	C	D	E	F	G	H	I	J
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										

Fig. 8. The testing 10 x 10 grid with 0.5 ft x 0.5 ft squares.

III. RESULTS AND DISCUSSION

The assembled platform was tested using BOLA^{TM} professional cricket bowling machine with different releasing speeds. The 10 x 10 grid system was used to map the ball's impact position, 18 meters away from the bowling crease. Fig. 9 (a) shows the setup placement on the synthetic pitch. Further, two observers were employed to track the impact position on the grid usingcameras precisely. Reference height of the batsman, grid and the feeder must be considered while using the platform; hence we allocated an offset for each component according to the platform height. The midpoint of the platform was placed aligned on the middlestump line.

The bounce from the synthetic pitch was recorded using the same grid as a control test and data present in Fig. 10. As shown here, we recorded data on three speeds of 70 mph, 80 mph, and 90 mph. The bounce variation on the pitch is analyzed in terms of the mean. We found that synthetic pitch shows lower bounce and lower variation compared to the artificial platform. Also, it possesses a trend of height incensement with increasing the bowling speed.

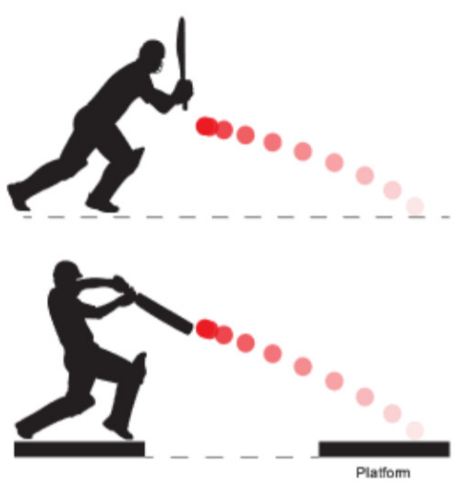

Fig. 9. Height references were taken into consideration while testing.

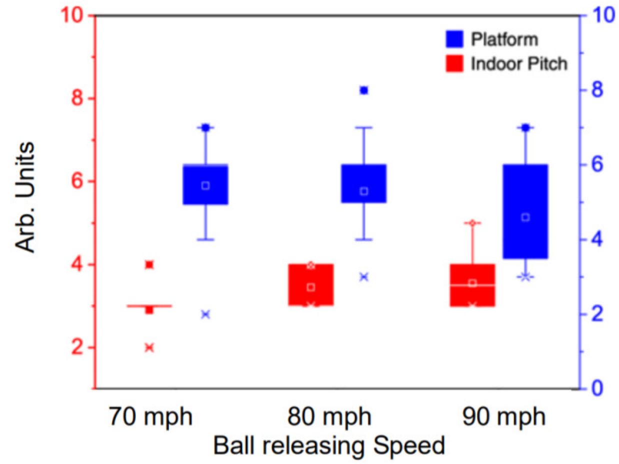

Fig. 10. Box plot of bounce for three sets of speeds on synthetic pitch (red) and platform (blue). Box represent inter quartile range (IQR), crosses represent min and max, line limits the 1.5IQR and circles represents outliers.

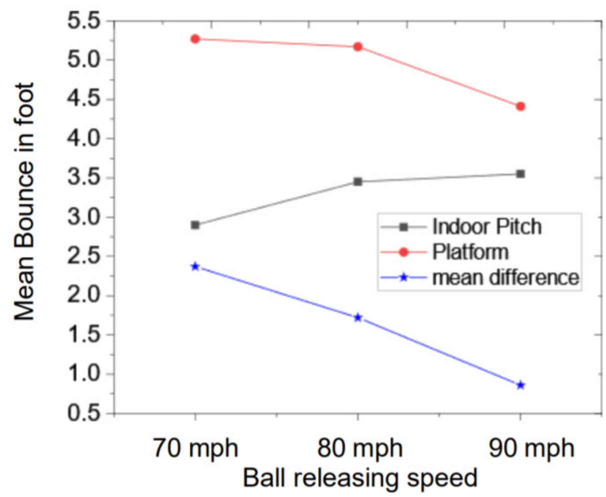

Fig. 11. Mean bounce with reference to the grid from synthetic pitch (black), platform (red), and difference (blue).

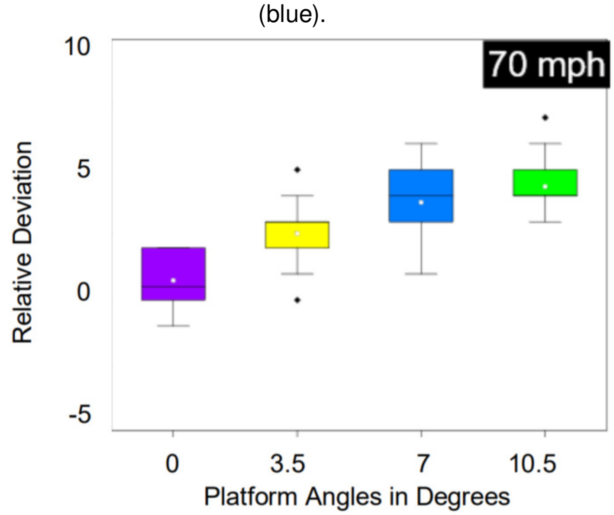

Fig. 12. Distribution of deviation vs. angle by the platform normalized to 0 degrees and -1 offset.

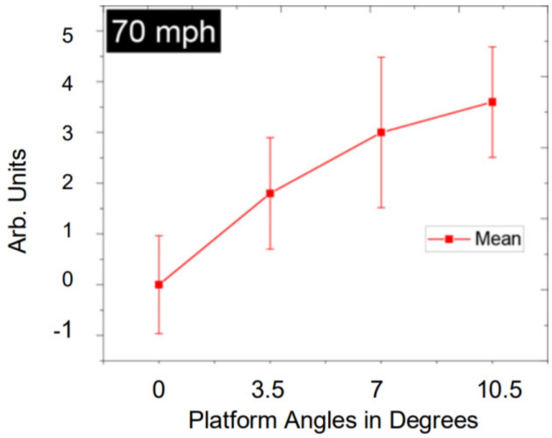

Fig. 13. Relative deviation amidst different lateral angles from the platform. (Later 0 degrees will be taken as the reference angle).

In comparison, the opposite is visible to be the case for the platform. Indeed, it should be highlighted that the sample size of each speed is 20; therefore, a single outlier may have a commendable impact on the mean values. We strongly believe more repetitions would give a more accurate grouping for the data. Also, we can explain the result in terms of the skidding nature of the surface where the synthetic pitch has an uneven micro surface compared with the iron plate; hence frictional forces acting on the ball may vary, and thus the skidding effect on the iron plate can be considered as higher than the synthetic pitch then the bounce becomes lower with higher speeds.

Further, the ideal situation to employ the platform is to merge it onto the pitch, where the reference height requirement will be nullified. As an alternative, building a small concrete stage for the batsman to hold the ground is acceptable.

Fig. 12 shows the deviation trend by the platform and the respective standard deviations. With the angle, the degree of variation is increasing non-linearly. These data were fitted using a polynomial curve fit of second-order, and we found that it follows Eqn. (1).

$$y = -0.0245x^2 + 0.6x \qquad (1)$$

Further, this put us into the consideration of saturation angle around 12 degrees. This relationship is used as one of the calibration curves for the automated rotational system. The Fig. 13 is the one that determines the height vs motor steps of the lifting jacks.

Table 1 interprets the data of a specific angle to the deviation of the ball. Using this data, we can create a relationship between a particular angle and deviation, and it can be used to calculate the platform angle to get specific deviation as Eqn. (2). Seam conditions in different countries are different. The user can use the above method, and practice sessions can be organized according to the relevant country's seaming conditions.

$$y = -0.02245x^2 + 0.5243x + 0.985 \qquad (2)$$

Also, the real-time demonstration of a batsman with the automated pitch shows how he reacts to higher bounce. With figure 14, we can identify weight transferring change of the batsman for same pitching position but with synthetic grass pitch vs automated pitch.

(a)

(b)

Fig. 14. Batsman weight transformer comparison (a) Batting without platform (b) Batting with platform.

There were several kinds of research done in the past few years to improve fast and bouncy conditions of a cricket pitch to demonstrate fast and bouncy pitch conditions. However, most of them were focused on enhancing the quality of soil conditions [4, 5, 11, 12]. Moreover, the speciality of the research presented in this paper is that we have focused on both the bouncing and seaming conditions improvements while most of the other researches focused only on the bouncy conditions.

Table 1: Seam Variation with the Platform Rotation Angle.

Platform Angle	Deviation (Arb. Units)	Deviation (ft)	Deviation (cm)
3.5°	$\frac{3}{4}$	0.88	26.81
7°	$2\frac{3}{4}$	1.38	42.06
10.5°	$3\frac{1}{2}$	1.75	53.34

When comparing with the other related researches, our research has mainly focused on a mechanical and mechatronic facilitated method to build a ball projecting platform.

IV. CONCLUSION

The statistical and real-time bouncing analysis in the ball projecting platform gives a marginal bounce improvement, and this clearly shows that this ball projecting platform can be used as a suitable practicing method to adapt the Fast-pitch bouncing conditions. Furthermore, considering the real-time demonstrates, it can identify that batsmen can use this platform to practice their weight transfer using this platform. However, the bouncing improvement due to the platform saturates at higher speeds.

The platform rotation facility also gives the expected required seaming conditions. The seaming effect can be adjusted as the required level of the batsman or practice session.

V. FUTURE SCOPE

The research was mainly focusedon initializing and testingthe success rate of this research idea. Moreover, we hope tomake the following improvements in the project for making a much better product.

— The ball can be projected using more accurate bowling machines like BOLA™ professional cricket bowling machine for the testing since JUGS™ cannot be used for much precise pitch positioning. Precise pitch positioning helps to create a better model of the behaviour of the automated pitch.

— Using a larger sample helps create better results and can identify the pitch's deterioration with a large number of practice sessions.

— The ball rotating mechanism can be improved by using a better lifting mechanism like a hydraulic jack or robot arm to maintain a constant movement throughout the operation.

— The microcontroller can be programmed to follow a pre-defined algorithm for the pitch rotation as a necessity. It helps to create a self-practicing session for batsmen by himself.

— When considering the ball's seaming variation, the defined algorithm can make more advance according to the characteristics of the batsman.

— Using artificial intelligence programming techniques, the developers can improve the algorithm for different batsmen batting patterns.

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Conflict of Interest. The authors confirm that there areno known conflicts of interest associated with thispublication of this paper.

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