An Embedded System for Bowling Performance Analysis in Cricket

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Abstract— **Sports Technology has advanced rapidly in the last two decades helping the professional and amateur athlete. But the more sophisticated the technology the greater the cost. In this paper, we have proposed an affordable solution alternative to the already available expensive technologies for the filed of Cricket. We propose an embedded system as an alternative for the expensive performance evaluating systems available in the market today used by bowlers in cricket. Individuals will be able to keep a check on their consistency as a bowler based on bowling parameters like line, length, and speed This system is developed by using a grid of Velostat polymer which is used as a sensor integrated with Arduino platform for the detection of the location of the ball's impact on the pitch. This tracks the line and length of the delivery. The data accumulated from these sensors are then used to present to the user using Data Visualization techniques making the data intelligible for the user.**

Keywords— ***Analysis; Bowling; Cricket; Length; Line; Matrix; Pressure; Sensor; Velostat***

I. INTRODUCTION

With today's technological advancement in each and every aspect of society, it has also affected the sports sector. This enabled technological applications in the field of sports and expansion in the training applications of players e.g. tracking the path of the ball, posture monitoring of players, Snickometer for edge detection, prosthetic devices for disabled players, etc. There are many technical approaches to enhance training and motion tracking in such environments. Typically, these rely on visual information, prior-knowledge of objects, or single force/torque sensors, e.g. image tracking used in football. However, these approaches generally are extremely expensive and not available for the common masses. With the use of traditional coaching system, there is only a single coach coaching multiple students with a general ratio of 1: 20, information of the various players cannot be retained by the coach, the individual focus cannot be given. The analysis of player data is crucial for the exploration of unknown faults and accuracy of player, which traditional coaching cannot give. The expensive system makes it hard for common people to take advantage of 21st Century innovations and tracking. In this paper, we propose designs for a low-cost device-"Cricket Bowling Analyser", which has been analyzed, tested and made cost-efficient.

II. RELATED WORK

Today there are many devices which help to control and develop the performance of players and help them achieve feats which were not possible in earlier times. Take the example of cricket, the statistics of modern players when compared to the old players are quite superior. Records are broken day in and day out. All this is possible only because of these devices which help us to learn more about the sport by

Providing the stats. But all this is available only to the few elite and not to the underprivileged. In a country like India, many people dream to become crickets but fall short due to various reasons the major one being low finances. Modern technologies like Hawk-Eye and Pitch Vision [1][2] are being used to analyze and access the performance of players. Hawk-eye uses six or more computer-linked cameras and the computer reads the video in real-time and tracks every aspect of the on-going game. On the other hand, Pitch Vision uses a sensor-based mat which is laid on the cricket pitch and is used for tracking the ball. But, both these technologies cost a fortune which can be affordable only to a few.

Hawk-eye is generally used for decision making of LBW in cricket, by checking where the ball pitched, the location of impact with the leg of the batsman and the projected path of the ball. Due to its ability of real-time coverage of the ball, hawk-eye is able to show the delivery patterns as well. Hawkeye comes with a price tag of approx. 2.3 crores INR[3].

Pitch Vision is a coaching aid which enables coaches to refer to videos, pitch maps, and wagon wheels to analyze their team and clients, driving player improvement and boosting results. It comes in several variants starting at 3 lakh INR and goes up to 10 lakh[1]

Table I. System Comparison

System	Technology	Hardware	Use	Cost (INR)
Hawk Eye	Image Processing	High-End Camera	Match	2.3CR
Pitch Vision	Embedded System and Image Processing	CAMERA, SENSOR MAT	Match and Training	3LAKHS
Cricket Bowling Analyser	Embedded System	Senor Mat	Training	30K

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III. METHODOLOGY

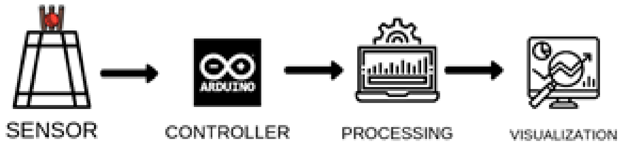

Fig 1. Block Diagram

The main goal of the system is to monitor and analyze cricket bowling parameters viz. line, length, and speed which are the essential parameters of the multi-faceted sport for any budding cricketer. This will help the player to access and improve upon his/her bowling engendering higher performances. Due to this system, the fundamentals of any cricket bowler will be tested and polished.

An embedded system is designed that uses pressure sensors developed using velostat to detect the location of ball impact which is then interfaced with the controller and the acquired data is processed appropriately and is used to give proper information about the line, length, and length of the delivery.

This processed data is also stored in the storage device and a specific directory is maintained for every user for all the overs bowled and this data is represented using data visualization techniques which provide a summary of the performance and help in better understanding the statistical data instead of mere table or spreadsheets. Data is stored for a longer duration which is helpful in tracking performance over a period of time which gives all the insights in the various trends that have taken place during this period.

IV. DESIGN OF SYSTEM

In the following, the underlying design criteria, materials, and design variants of our project are described.

A. Design Goals

To determine the requirements for the pitch sensor, we considered several use cases, which are described shortly in the following.

1) To locate the ball impact to determine the length of the delivery.
2) Sensor mat should not affect the ideal pitch conditions.
3) Calculating the speed of the delivery.

In our opinion, essential requirements are low cost and the ability to manufacture the sensor mat with economical tools and materials.

B. General Concept and Materials

To enable support for static as well as dynamic pressure measurements, the sensor is based on the piezoresistive effect. The electrical resistance changes of this piezoresistive material upon application of pressure. The resistance is measured via copper on both sides of the sensor-layer. To achieve a 3D model, many such copper strips are arranged next to each other. In order to keep the number of necessary connecting wires low, we use the commonly known matrix-structure. By selecting the right combination of vertical and horizontal wires, the resistance for each strip in the matrix can be measured. To further reduce the wires, multiplexer were.

Based on the design goals, we restricted ourselves to the use of commonly available and low-priced materials. We used retail prices to evaluate the overall costs. For larger volumes, costs may be significantly lower. The search led to the Velostat (50000 ohm, 8 mils), which is produced by 3M[4][5] and consists of a polymeric foil (11µm thickness) impregnated with carbon black. For the electrodes, we use a copper sheet strip (40 microns), which is also commonly available. The outer protective layer is made of a plastic flex.

C. Senor Prototypes

We built and evaluated several prototypes for the overall assembly of the sensor element. In the following, the best design in terms of accuracy, manufacturability and low force thresholds, is described:

The structural composition of this prototype is depicted in Fig. 2 for the matrix. Each vertical and horizontal strip overlaps at exactly one point, where one of the strips is on the upper side of the polymer and the other on the lower side. The sensor element is wrapped in a plastic flex to protect it from impact. The cover is glued to the inner layers using a polyester tape to preserve its flexibility.

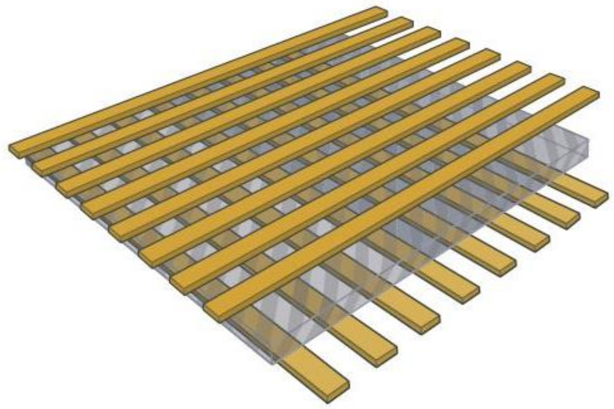

Fig 2. Assembly of the sensor prototype using velostat sandwiched between copper strips

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V. IMPLEMENTATION

The primary task of the system is to measure line, length, speed of delivery. For measurement different sensors are interfaced with microcontroller to acquire the data.

A. Pressure Sensing Mat

Pressure sensing mat is designed using velostat polymer. The aim of this sensor is to give the exact location at which pressure is applied. Matrix structure[6][7] of the mat is helpful in finding the location of pressure change. The sensor will return 2D coordinates of the location of pressure change. A number of copper strips are used as rows and columns and the velostat polymer is sandwiched between the copper strips to create the pressure sensing matrix. The mat used in the system consists of a matrix structure with 30 rows and 12 columns. The data given by this matrix is used to track the length of delivery. Another matrix of 12 rows and 9 columns is used to measure the line of the delivery. The 30 rows X 12 columns mat used for determining the length of the delivery is placed on the pitch and the 12 rows X 9 columns mat is placed behind the stumps on a vertically oriented screen which helps in determining the line of the delivery. The matrix structure is interfaced with the microcontroller using analog multiplexer mux506[8]. The multiplexers are used to control the input and output of the matrix. The rows and columns of the matrix are connected to the channels of a separate set of multiplexers responsible for controlling rows and columns independently. The row section of the matrix is used as input and the columns are used to measure the output.

Tabel II. : Dimensions and Specification

Pitch Map				
Copper Strips		Length (cm)	Breath (cm)	No of Strips
	ROW	75	3.5	30
	COLUMN	180	3.5	12
Velostat		Length (cm)	Breath (cm)	
		180	75	
Back Screen				
Copper Strips		Length (cm)	Breath (cm)	No of Strips
	ROW	75	3.5	12
	COLUMN	75	3.5	12
Velostat		Length (cm)	Breath (cm)	
		75	75	

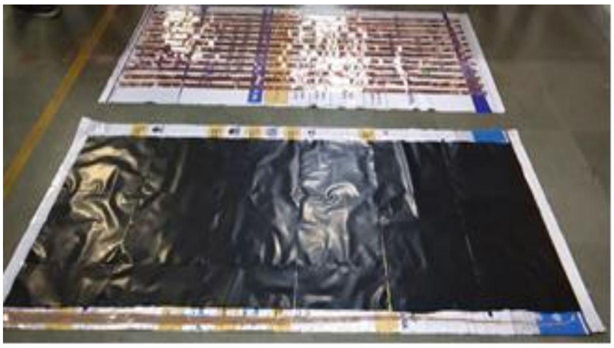

Fig 3. Velostat placed between copper strips for pitch mat

The operation of pressure sensing matrix is dependent on the change in impedance of the polymer, according to the ohm's law voltage is directly proportional to impedance, using this law the voltage change at the location of ball's impact is monitored using the mux.
The microcontroller sends a 5V input signal to multiplexers which control the switching of rows. The signal is transferred to one channel at a time and the columns are continuously monitored for detecting any major surge in voltage. This voltage surge from the multiplexers is fed into the microcontroller.

Fig 4. Velostat placed between copper strips for back mat

B. Speed using Ultrasonic sensor

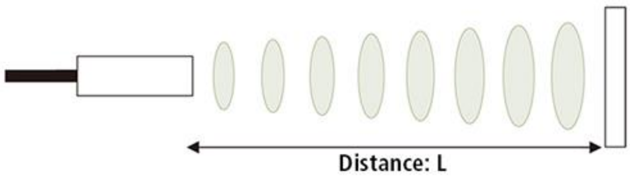

Fig 5. Ultrasonic waves from the sensor

The ultrasonic sensor is placed on the stumps facing towards the bowler. The sensor continuously emits ultrasound, when the ball is bowled the sensor detects the ball twice, one at distance d1 and one more time at distance d2. So, only two waves reflected back at the distances d1 and d2 are considered. This enables us to determine the time between the two distances and hence the speed of the delivery.

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VI. RESULTS

Using Processing3 Visualisation software we display the real-time location of the ball.

Fig 6. shows live visualization of real-time delivery. The bottom pitch is divided into 4 section which shows the length of delivery viz. Yorker,full,good,short.The back screen is divided into 3 section which shows the line of delivery viz. off, middle, leg.

The black box in the image shows the exact coordinates of the delivery and the color code helps in deciphering the length and line of delivery.processing3 also collects the data from Arduino and loads the data into a CSV file.

Fig. 7 shows the format in which data is stored in CSV files. The line and length data from the processing software is stored along with date and time instantaneously when it was acquired. This CSV file helps in long term storage of data and this data can be retrieved later for further graphical analysis.length_x and length_y represents the x,y coordinate of the length of a particular delivery similarly line_x and line_y gives the x,y coordinate for the line. The date-time stamp is added for aiding the processing of data for generating graphs.

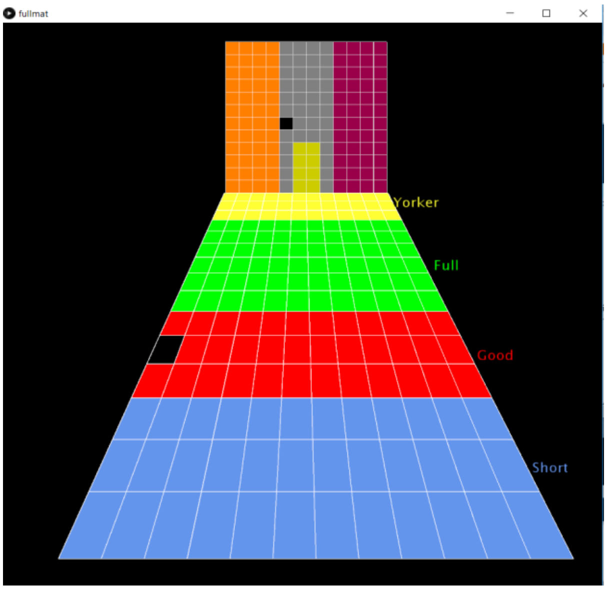

Fig 6. Processing3 visualization

	A	B	C	D	E	F	G
1	Date	Time	Length_x	Length_y	Line_x	Line_y	
2							
3	04-05-2019	10:01:03	0	0	4	8	
4	04-05-2019	10:01:04	0	0	5	7	
5	04-05-2019	10:01:04	0	0	6	8	
6	04-05-2019	10:01:06	0	0	5	8	
7	04-05-2019	10:01:10	14	0	5	8	
8	04-05-2019	10:01:11	11	0	5	8	
9	04-05-2019	10:01:12	8	2	5	8	
10	04-05-2019	10:01:13	6	3	5	8	
11	04-05-2019	10:01:13	9	1	5	8	
12	04-05-2019	10:01:13	9	0	5	8	
13	04-05-2019	10:01:13	9	1	5	8	

Fig 7. Result Stored in CSV files

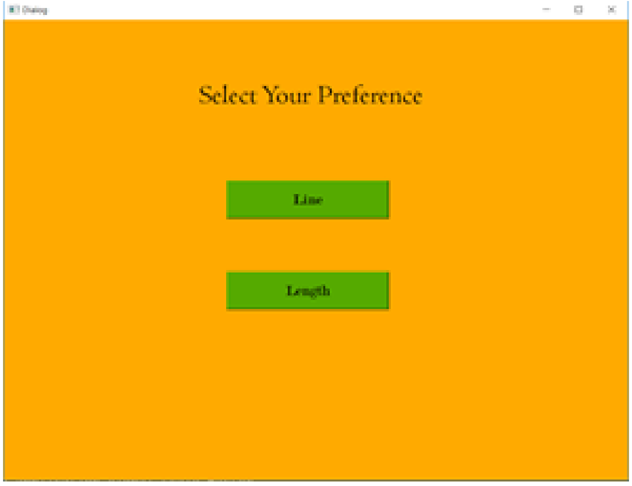

Fig 8. GUI

The above figure represents the homepage of GUI(Graphic User Interface) which is designed for end-user to access the system for obtaining performance stats and summary.

Graphs are used to provide a visual representation of the delivery to the user for later reference and getting an overview of performance for each over new graphs are generated after every over.

On average, the ball takes approximately 11 ms to bounce off the pitch. Our system can detect whether the ball has bounced on the pitch if the bounce time in 11 ms. That is, the Arduino scans the enter mat (both mats) in 11 ms.

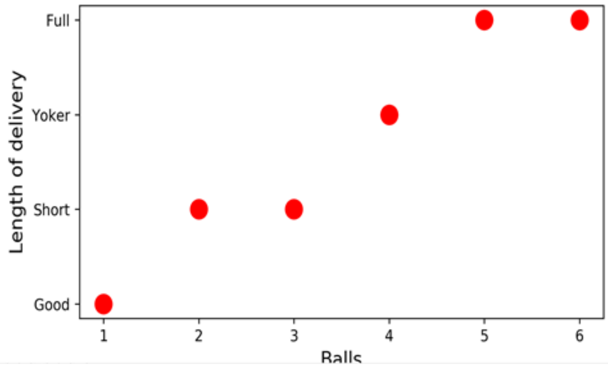

Fig 9. Line of delivery for 1 over

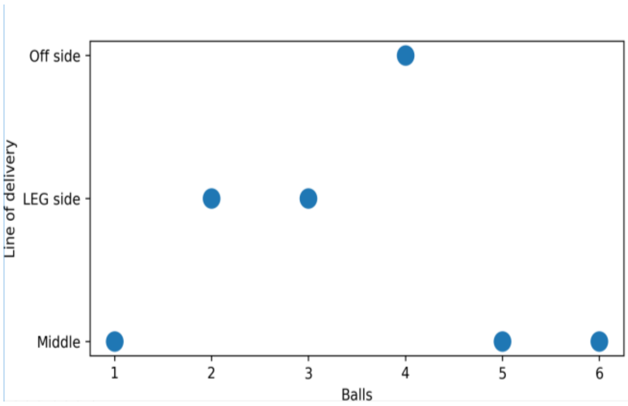

Fig 10. Length of delivery for 1 over

VII. CONCLUSION

The proposed system Cricket Bowling is a low-cost alternative which can help in monitoring of bowling system which can effectively calculate the basic 3 parameters of the cricket coaching system. Self-fabricated Sensors are used to detect the delivery balls. Furthermore, the user can monitor the individual balls continuously and the status of the ball's location is updated in real-time. Therefore, this proposed system can overcome the traditional method of a single coach system. At the same time, it offers cost savings and reliability which convince the users all the time. The advantages consist of personalized cricket coaching system and tracking.

VIII. FUTURE SCOPE

1) This system can further be improved by upgrading the speed measurement equipment, which currently works on the not so reliable ultrasonic sensor.
2) The speed can be measured using a more reliable radar-based system using the concept of Doppler shift.
3) Additional equipment can be utilized to provide a 3D trajectory of the delivery.

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