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Improving Accuracy and Speed of Crease Decisions in Cricket Electronically

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Abstract - Technology has touched every aspect of life in the twenty-first century. An industry as atypical as sports has been no exception to that. Be it a simple stopwatch used in a 100m sprint, or the complex Goal-line technology used in Football, it has revolutionized it all. Cricket has also come a long way with technologies like Hawk-eye, Snickometer, etc. Albeit we have a long way to go in order to achieve perfection, as we are yet to have a foolproof technology for detection of No-balls. We can certainly do better to explore it. This paper is a mere effort in that direction. The No-ball is currently judged by the on-field umpires in Cricket. Hence, the human limitation is a major stumbling block in justifying the No-ball decisions. The main objective of this paper is to propose a system that will help on-field umpires to judge No-balls correctly with the help of a micro-controller and some basic sensors.

***Key Words*:** Cricket, No-ball detection, Micro-controller, LASER, Photoresistors, Servo-motor, .

1. INTRODUCTION

There are very few incidents that account for more heartbreaks than those in the world of sports. Be it Football, Cricket or any other sport, the passion of those who witness it live is unmatched. They go wild in joy when their favorite team wins or get frustrated to the same degree if their team loses, and more so if there's injustice in some of the important decisions. So, it becomes imperative for those in charge to deliver fully justified decisions as every single one of those significantly affects the outcome of a game.

In Cricket, huge efforts have already been made to rectify these matters such as the ball-tracking technology which was invented to decide whether the batsman is guilty of Leg-Before-Wicket (LBW). Similarly, a Snickometer can clearly show even if there's a tiny bit of edge between the bat and the ball in case of caught-behind wicket. And not to mention numerous cameras helping in scenarios such as Run-outs, boundary infringements and borderline ground catches. While all this undoubtedly seems exceptional, the most frequently occurring is the problematic matter of deciding No-balls which remains to be given enough attention. To get this picture a bit clearer, let us shed some light on one of the many controversies in this sphere.

On the very last delivery of a crucial game between Royal Challengers Bangalore and Mumbai Indians in the Indian Premier League (IPL) in 2019, Lasith Malinga was guilty of overstepping (Fig- 1) and that too, by a considerable margin. The on-field umpires missed the trick to spot this all important No-ball and to be fair to them, it's not always a straightforward decision to make. Nonetheless, this burst out a big bone of contention as the match at that time was on fringes and any team could have won it.

Fig- 1: Front-foot no-ball in IPL 2019 (right) that caused one of the many major controversy and experts of the game started rethinking the current methods of making decisions related to front-foot no-balls (left).

As mentioned earlier, this is just one of many such events. Hence, it becomes imperative and it's about time that we amend these decisive moments in the second most popular sport in the world with the help of technology.

2. Prerequisites

In order to understand working of the proposed system, one needs a rudimentary understanding of the game of cricket, the cricket pitch, and the concept of a front-foot no-ball.

a) The Game of Cricket

In the game of Cricket[1], two team of eleven players[2] each play against each other. The cricket ground has a 22 yards long and 10 feet wide pitch at the center of the ground where a bowler of one team bowls and the a batsman of the other bats. A coin is tossed before the game begins. The captain of the team who wins this toss decides if his team will bat or bowl first. The team batting first tries to score as many runs as they can unless ten of their players are declared "OUT" or unless they exhaust the total number of overs. The total number of overs depend on the format of the game being played. The second team, at the same time, has the task of making sure that the first team scores as less runs as possible. The roles are reversed after the this. In international matches, two on-field umpires[3] are tasked with making decisions during and after every single ball.

b) Cricket Pitch

In Cricket, we have a rectangular pitch[4] that is 22 yards long and 10 feet wide. It is demarcated by white marker lines painted on the middle of the field. These markings indicate where a batsman is supposed to bat and from where a bowler is supposed to bowl. The general term used for these markings is crease. The specific crease that we need to focus on in this paper is called the popping crease. A popping crease is marked at both ends of the pitch and indicates the position where a bowler is supposed to bowl from and also the lines between which a batsman needs to run in order to score runs.

c) Front-foot No-Ball

In total, there are ten different kinds of no-balls[5] in cricket. But we shall focus on the most common kind of no ball, that is the front-foot no-ball. An umpire declares a ball bowled by a bowler a no-ball if the heel of the front-foot of a bowler lands ahead of the popping crease.

d) Recent Developments

In the past two decades, Cricket has adopted various technologies to assist umpires in the decision making process. International Cricket has gone from introducing a “Third Umpire”, who makes use of video replays in order to make decisions in high speed and highly dynamic situations, to using thermal cameras in order to find out if the ball has made a contact with the bat while making a decision on Leg Before Wicket (LBW) out[6].

At the same time, hardly any progress has been made in terms of how decisions on no balls are made in the game of Cricket. Apart from the fact that video replays are used to verify if a player was out, it is still only used for that particular situation and only if the on-field umpire explicitly requests it.

So far we have seen three techniques used for no-ball detection, but none of them were good enough to be accepted and implemented on a large scale. One was put forward by Wazir Zada Khan, Mohammed Y Aalsalem, and Quratul Arshad in which they make use of three sensors to detect no-balls[7][8]. Two of them were installed on the pitch while one was installed in the shoe of the bowler. Although the two sensors on the pitch were not a problem, the sensor in shoes posed a problem because it meant modifying every single player’s shoes which was not feasible. The second method was proposed by Mohanlal S Malu and Kailas G Dangi, who proposed using the crease itself as a sensor by placing sensors below both the popping creases[9]. This system failed as it declared a perfectly legal ball as a no-ball if the bowler had stepped behind the popping crease, which, according to the rules, is not a no-ball. The third system was developed by AZM Ehtesham Chowdhury, Md Shamsur Rahim, and Md Asif Ur Rahman, who proposed using the broadcast cameras and computer vision to determine the legality of a ball bowled[10]. This technique is not adequate because the fielders have a freedom to stand anywhere on the ground which, a lot of times, hinders the decision making even using conventional video replays. Using computer vision will not give any results better than the existing system of video replays. Fig- 2 gives an instance when one such incident took place that neither of the cameras on the two opposite ends could give a verdict on if it was a legal ball or a no-ball when a video replay was requested by the on field umpire. One side of the popping crease was not visible to the cameras due to a fielder, while the other side was not visible to the camera due to the bat of the batsman on the non-striker’s end (Fig- 2).

Fig- 2: The foot of the bowler was not visible to either of the broadcast cameras that are set up on both the sides to assist in decision making. A fielding player was unknowingly blocking the view from one side, while the bat of the non-striker was blocking the view from the other side.

In this paper, we have proposed a system that uses LASERS, microcontrollers and a vibrating wrist band that helps the on-field umpire in making instantaneous decisions that are extremely fast as well as highly reliable, even for the second most popular sport in the world.

3. Proposed System

One half of the system that we have proposed consists of an assembly of a Microcontroller, LASERs, Photoresistors, Ultrasonic Sensor, Servo-motors, and a Bluetooth module installed right on the pitch as shown in the figure below (Fig-3). The wires connecting all these, the Microcontroller and the Bluetooth module are all under the pitch and hence are not shown in the figure. There is an intricate system of wires already in place under the pitch which is used by the broadcasters to connect the stump camera and mic, so adding wires of one more system will not be a problem. This half of the system is responsible for making the decision on whether a given delivery is a legal ball or not.

Once the microcontroller makes a decision, it must let the umpire know if the ball just bowled was a legal ball or a no-ball. Hence, the second half of this system consists of a Bluetooth wristband on the wrist of umpire which will vibrate for 2 seconds if a player oversteps the popping crease and is guilty of bowling a front-foot no ball. The greatest advantage of the system proposed in this paper is that it gives a verdict in a matter of milliseconds, which is very crucial because ideally, an umpire is expected to declare a no-ball as soon as it is spotted. We have named this system, “The Crease Decision Assistance System” or CDAS in short.

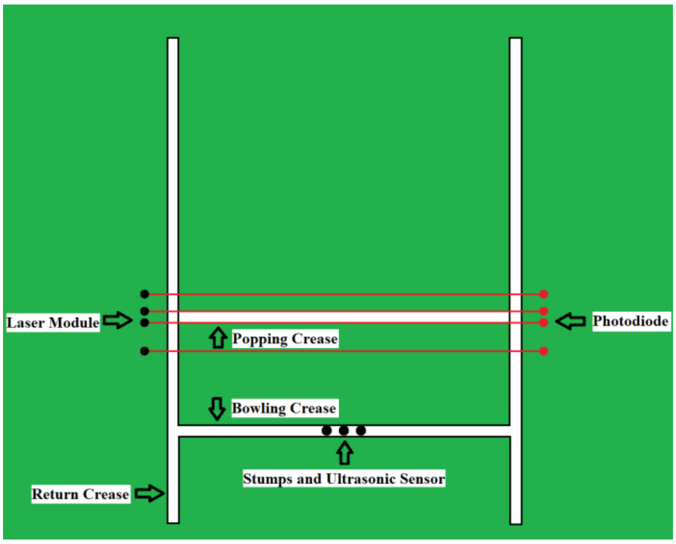

Fig- 3: A part of the system that will be installed on the pitch itself. Do note that the microcontroller and the Bluetooth module, along with the wires that connect all these other parts, are hidden underground.

In the CDAS, we will use four pairs of LASER modules and Photoresistors which will be five millimeters above the ground level. Four lasers are placed as shown in the figure above, such that they point directly at the photoresistors, hence the resistance offered when nothing is between the two of them is extremely low. This alignment is ensured using an assembly of servo motors. But when a bowler steps on the popping crease, some of these lasers are cut by his/her foot because the foot comes between one or more of the four lasers. Hence, the resistance of the photoresistor corresponding to the LASER that has been cut increases. Now depending on which of these LASERS are cut, and in accordance with the rules of a front-foot no-ball in the game of Cricket, the microcontroller determines if the ball delivered was a legal ball or a no-ball. According to the rules, a bowler’s foot must have completely landed ahead of the popping crease, meaning, even if a small portion of his heel is on the popping crease, it is termed as a legal delivery. All the possible scenarios and whether the verdict for each of the scenario will be a legal ball or a no-ball according to the CDAS have been shown in the figure on the next page (Fig- 4). It is worth mentioning that the accuracy of the CDAS is up to 1 millimeters. In other words, it can successfully differentiate between a legal ball and a no-ball that are just 1 millimeter apart.

Apart from that, the assembly also consists of an ultrasonic sensor (HC-SR04) which will be fitted on two of the three stumps, other than the middle stump. They will point in the outward direction, i.e. the ultrasonic sensor that will be placed on the left stump will point towards left (left direction as per Fig- 3) and the one on the right stump will point in the right direction (right direction as per Fig- 3). The job of this ultrasonic sensor is to sense a bowler coming towards the popping crease, and as soon it senses a bowler approaches the popping crease, the microcontroller will turn on the LASER-Photoresistor assembly. The logic behind using this proximity sensor is simple. The system needs to be on only when the bowler has passed the stumps during his run-up. If it is turned on before or after the bowler’s run-up, we will get false triggers due to other players who are on the ground as well. So, this solves that problem once and for all. Also, it works because before a bowler bowls a delivery, he has to pass the stumps, and so if the threshold for turning on the LASER-Photoresistor assembly is 5 feet (which is the width of the pitch to either side of the stumps and well within the range of the aforementioned sensor), the LASER-Photoresistor assembly will certainly turn on without fail. This reduces the number of false triggers by a significant factor. Now that we have explained what its job is, let us move on to how it will do its job. The ultrasonic sensor, along with the Bluetooth module used in this system, are the only components that always stay on. The ultrasonic sensor continuously senses how far the nearest object is from it. The microcontroller keeps on receiving values of how far an object (a player in this case) is from the stumps. As soon as the microcontroller receives a value of less than a threshold value (which we will set as 5 feet as it is the length of the pitch from the stumps), it knows that a bowler has reached the stumps and is about to bowl a delivery, and the microcontroller turns on the LASER-Photoresistor assembly in order to get ready to give a verdict on the legality of the upcoming delivery. We have made this assumption because in almost all cases when a player comes in close proximity with the stumps, it is a bowler who is about to bowl a ball. This assembly remains on only for five seconds if the foot does not land on any of the LASERs. This ensures that even if some other player comes in proximity of the stumps when a ball is not being bowled, the system will turn off and will be ready to sense the bowler when he is ready while still ensuring reduction in false triggering.

The remaining components are the microcontroller, the Bluetooth module, and the Bluetooth Wristband worn by the umpire. The functioning of the microcontroller has already been explained while explaining the functioning of the LASER-Photoresistor assembly and the Ultrasonic sensor. Apart from that the microcontroller is also responsible for transmitting a signal to the wrist band of the Umpire using the aforementioned Bluetooth module. This signal will only be transmitted if the ball bowled is a no-ball. So, when a no ball is bowled, a signal will be transmitted from the microcontroller to the umpire’s wrist band, which will in turn start the vibrating motor of the wrist band for two seconds and the umpire will be alerted in a matter of milliseconds that a no-ball has been bowled.

Now that we know the function and working of every single component, let us look at the chronology of working of the CDAS as a whole. After the system is turned on, we pair the Umpire’s wrist band with the Microcontroller’s Bluetooth module. After the pairing is successful, the ultrasonic sensor gets turned on and starts sending values of distance of the objects (players) in its proximity to the Microcontroller. When a bowler starts his run-up, and reaches the stumps, he is within the predetermined threshold distance (5 feet) that we have hard-coded in the microcontroller. At this point of time, the microcontroller receives a distance smaller than the threshold distance from the Ultrasonic sensor, meaning that the bowler is about to reach the popping crease. At this very moment, the microcontroller turns on the LASER-Photoresistor assembly and waits for the bowler to cut either of the LASERs with his foot. Once one or more of the LASERs are cut by the foot of the bowler, the microcontroller gets to know which of the LASERs have been cut by the foot of the bowler. Depending on that, the microcontroller takes a decision on whether it was a legal ball or a no-ball depending on a predetermined algorithm (the algorithm has been visualized in Fig- 4). If it is a legal ball, the microcontroller does nothing, but if it is a no-ball, the microcontroller sends a signal to the Bluetooth wrist-band worn by the Umpire and the wrist-band vibrates for two seconds, indicating that the ball just bowled was a no ball.

The flowchart in the figure on the next page (Fig- 5) is a simpler explanation as to how the CDAS works.

The accuracy of this system is 1 millimeter. Which means, even if the difference between the foot in case 8 and case 9 of the figure below (Fig- 4) is 1 millimeter, the CDAS will still give an accurate and distinct result for those two cases.

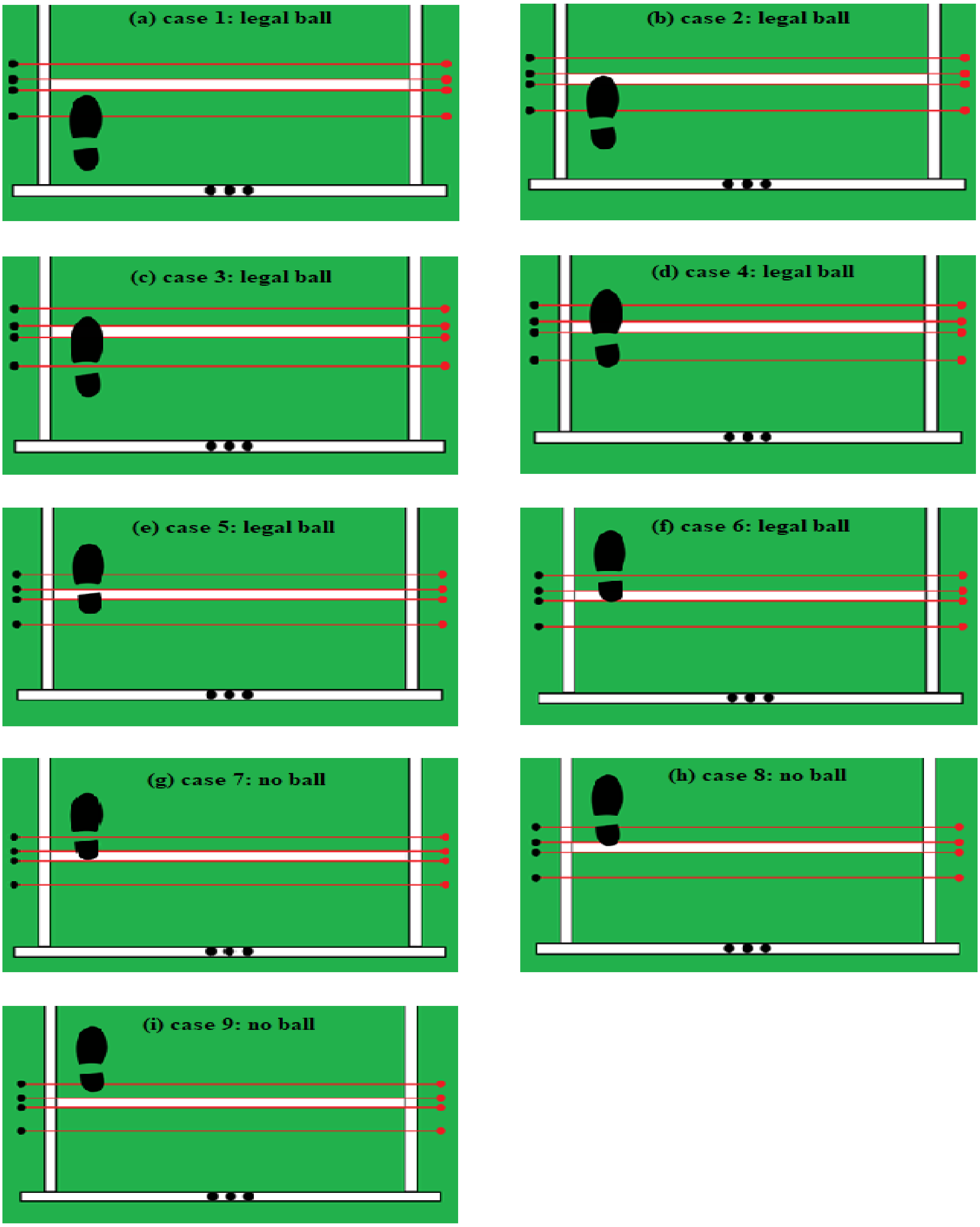

Fig- 4: The various cases of front-foot stepping of the bowler and the verdict on the legality of the ball in accordance with the rules of Cricket.

It is clear that this system has eradicated the shortcomings of the three existing systems, that we discussed in Section 2 (d), that have attempted to solve this very problem. W. Z. Khan and his team attempted to solve this problem using sensors that were installed on the pitch as well as the shoes of the bowler. We solved the major problem, which was low feasibility of sensors in shoes, by eradicating the need to use sensors in the shoes altogether. On the other hand, M. S. Malu and his team proposed a method that involved a system which used a set of sensor below the popping crease. This system could not distinguish between a bowler stepping ahead of the popping crease and behind the popping crease. Although a bowler stepped behind the popping crease, it would declare that a no-ball. Unlike that system, the aforementioned CDAS can distinguish between the two. Lastly, A. E. Chowdhury and his team made use of broadcast cameras, which, as we have shown previously, is not foolproof. We have designed a system which, unlike any other existing system that works to solve this problem, solves the problem while easily facilitating installation using the existing technology and is so user friendly for the Umpires that it needs almost no prior training for them to be able to use it seamlessly from day one.

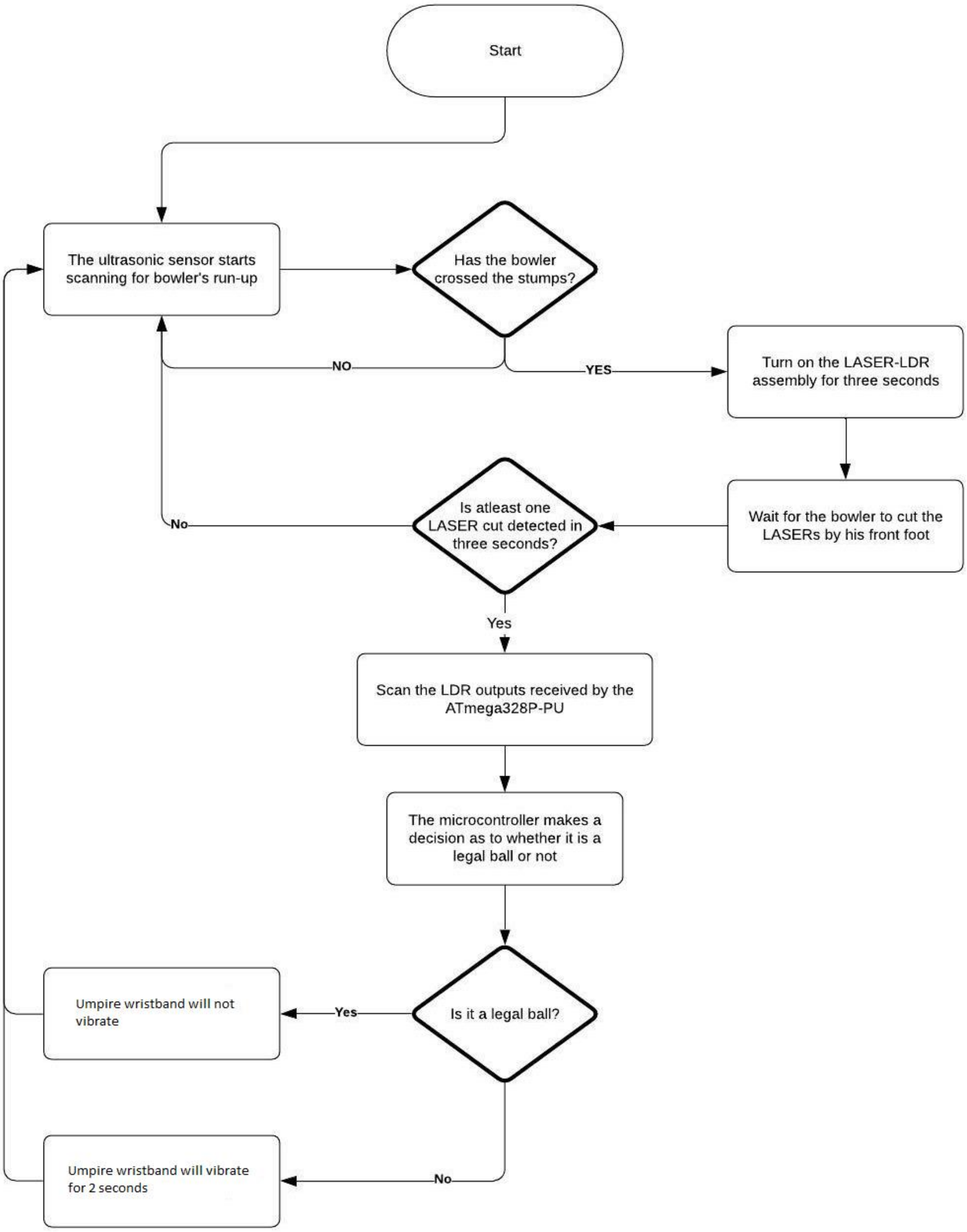

Fig- 5: Flow-chart of working of the Crease Decision Assistance System

Component	Quantity	Cost (in INR)
ATmega328P-PU IC	1	300
Ultrasonic Sensor HC-SR04	2	400
HC05 Bluetooth Module	1	700
Laser Module 650nm	4	800
Photoresistor	4	40
AC to DC Converter	1	250
Bluetooth Wrist Band with Vibrator	1	1000
Servo Motors	2	400
Printed Circuit Board	1	350
Wires	N/A	250
Cost of Installation	N/A	2000
Miscellaneous	N/A	1000
Total Cost		**Rs. 7490**

Table 1: Total installation cost to install the system on one of the two popping creases.

One of the major factors that determine the feasibility of a system is its cost. Table 1 shows that the total cost to install this system at one of the ends of the pitch comes out to around Rs. 7490. Which, at the current (August 2020) exchange rate, is equivalent to just 100 US Dollars. Two such systems need to be installed at each ends of the pitch. So the total cost to install this system comes out to be around 200 USD. Cricket is the second most popular game in the world which has systems worth thousands of dollars in place so that they can facilitate decision making during rare incidents like LBW, caught-behind-wicket, etc. Hence, a sum of 200 US Dollars sounds like a bargain for a technology so important that it will be used on every single ball bowled during the match.

4. CONCLUSION

The proposed system design attempts to eliminate human limitations to judge a no-ball correctly. The system does really well in terms of accuracy as it has covered all the borderline cases of legality of a delivery bowled by the bowler. Moreover, it has been achieved using a limited number of resources and in a very cost-effective way. The system needs to be judiciously applied to achieve its objectives because in all fairness, the final say in the decision should always lie in the hands of on-field umpires. Although the system is not refined to the degree that the International Cricket Council (ICC) will directly adopt it for International Matches, but it is ready to deployed in empirical stages in domestic cricket matches. It is also noteworthy that this system is near-perfect and will not need major changes to be embraced by the Cricket community, and it will not be long before we come up with slight tweaks in this very system that will ensure that it is ready for deployment during International matches. Also, it's worth mentioning that the CDAS will go a long way in helping bowlers improve their accuracy in practice sessions, in the absence of umpires.

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