Cricket Batting Technique Analyser/Trainer: A Proposed Solution using Fuzzy Set Theory to aid West Indies Cricket

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Abstract: - Cricket has been a unifying force for the countries of the West Indies. However, from being the world champions the West Indies are now just struggling contenders. As the world becomes more technologically dependent, there have been numerous systems to enhance performances in various sports. In this paper a system is outlined that aids in the execution of cricket batting strokes. From an analysis of batting strokes, a mathematical classification of two batting strokes, using fuzzy set theory, is carried out. From the information provided by this classification a batting training system is suggested. This system captures the motion of a batter whilst playing a stroke. This is then compared to known strokes and feedback is provided which outlines how well the stroke was executed.

Key-Words: - Cricket batting, fuzzy set theory, batting stroke classification, expert system.

1 Introduction
The West Indies was the dominant force in world cricket from the early seventies to the early nineties [1]. Sadly, since the nineties there has been a sharp decline in the performance of the team. From January 1980 to November 2002 the West Indies played 167 test matches. 85 of these were played between January 1980 and November 1995, of these there were 41 wins, 17 losses and 27 drawn matches (a percentage of 48% wins, 20% losses and 32% draws). The remaining 82 matches were played between November 1995 and November 2002 resulting in 20 wins 34 losses and 28 draws (24% wins, 41% losses and 35 % draws). Since that date they have had 9 wins, 34 losses and 13 draws (16% wins, 61% losses and 23% draws) [2]. It has been suggested that this decline is due to a lack of proper training facilities and that the major problems are in the batting aspects of the game [3].
The aim of this research is to produce a system to assist the coach or trainer in improving how well a batter executes cricket-batting strokes. It is important to note that this system does not focus on the selection of the stroke but more on its execution. The focus is first on batting strokes against fast bowling and two strokes are analyzed.
First we require a means to measure how efficiently the cricketer plays a particular stroke. This is achieved through using a measurement system that supplies a means of comparing the cricketer’s action to a standard reference. In this research, these reference values are obtained from a combination of a number of sources. These are the description of the motion provided by the coach or trainer, coaching literature [4], [5], [6] and by analyzing the motion of more experienced batters. It is assumed that the more experienced batters execute the motion with greater efficiency. In all cases, specific detail for the different postures throughout the execution of the stroke is required.
First a detailed classification of all the batting strokes in response to fast bowling is produced. These descriptions for each stroke are obtained based on the coaches/trainers definition. Two strokes are looked at in detail, the cover drive and the forward defensive. Initially crisp sets were used in the classification as a means of catering for the vague definitions required for the descriptions of each stroke. This now makes it easier for the comparison of the measured quantities for these motions to the reference sets that were created. From this a computer software program is developed that compares the actual to the measured results. The motion of an experienced batter, whilst playing the particular stroke, is captured and compared to those stipulated by the coach. The discrepancies are analyzed and a final set of reference values is then produced.
2 The Game of Cricket

Batting in cricket involves hitting the ball with a bat around the ground to score runs. Depending on where the ball pitches, its speed, the height of the bounce and its lateral movements with respect to the pitch, the batter will play a particular stroke (different orientation and swing of the bat). Figure 1 shows a bird's-eye view of the second half of a cricket pitch with the bowler bowling from left to right to a right-handed batter (facing the ball with the feet position shown). The pitch is divided into sections representing the different bowling length (where the ball first makes contact with the ground).

2.1 Current Batting Training Systems

Over the years there have been numerous advances in sports training methods and in particular cricket. Typical training systems will involve an analysis of the player's current motion/technique. This is then used to suggest corrections and the system is also used for monitoring the implementation of the correct technique. This analysis may be subjective, objective or predictive, [8] explains these, and should result in the encouragement of proper technique, which is important for the prevention of injuries and for achieving optimum efficiency in the execution of a particular motion.

The ability to reproduce the same motion over and over again is very important in cricket. It has been shown [9], that an expert batter is more effective than a novice in identifying different types of deliveries. Cricket Batting Training systems are designed to give a novice batter the experience so that he/she can be more effective in their shot execution.

Information provided by the coach of the Jamaica youth team indicates that the main thought and thrust behind the development of the young batter is how to effectively reproduce a particular stroke. The different elements of the particular stroke is illustrated to the player. This is done with reference to the type of ball being bowled. The player is taken through the sequence of motion throughout the dynamics of the ball [6]. This is done by both video analysis and practical demonstration. The conditions (type of ball etc) are then set up by the coach and the player is evaluated on how well the stroke was executed. This evaluation may be in the form of video playback where the coach points out to the players the areas of error and/or the coach may also show by demonstration the batter’s errors.

In most cases this video playback is only two-dimensional and there is not a thorough analysis of all the aspects of the player’s motion for the stroke and the accuracy in the coach’s demonstrations is revealed in the coach’s ability to consistently reproduce the particular stroke. The research reported on in this paper looks towards developing a system whereby the batter’s motion can be compared to a consistent reference system.

2.2 Stroke Selection

It has been reported that in sports that involve hitting a ball there are three key factors that allow an athlete to move readily into position to execute a hit [7]. These are un-weighting, cuing and balance. Un-weighting refers to the lowering of the athlete’s body by the bending of the knees to be able to quickly move. In cricket this is referred to as the crouch or stance. This is the initial position taken at the crease.
Cuing is the process whereby the ball is tracked and its path evaluated. In cricket this is the process whereby the batter evaluates the type of ball being bowled by the bowler. According to [10], attention to early clues by the action of baseball pitchers is critical to batting performance. The eyes are very important in tracking and they tend to change focus and track the ball while the head remains still. It has been shown that the practice of cuing will enhance a player’s performance [11]. Balance refers to the ability of being able to move quickly to different positions as needed. This is essential in all sports. During the initial positions (stance in cricket) the centre of gravity is between both legs. This affords the athlete the ability to transfer the weight to either foot and allow for the ease and quickness of motion that is required to perform effectively.

Playing efficiently in cricket is achieved by knowing the type of ball being bowled and hence selecting the correct stroke. This must be followed by the flawless execution of the stroke. The pitch, the weather, and the bowler’s form can be summed up in the type of ball being bowled. The possible variations of these, for fast bowling, are shown in Figure 1. There are occasions when the bounce and lateral movements are different from those expected and this may be due to changes in the pitch, weather or even the bowler's form. This will produce problems for the batter in the stroke selection, but this should not affect how well the stroke is executed.

The batter’s form is reflected in how well the stroke is selected and executed. It is the ability to quickly assess the conditions of the pitch, weather, fielding positions and bowler’s form that allows for the correct deduction of the type of ball being bowled. This will then allow the batter to select the optimum stroke and execute it.

The score or the state of the game is also important in determining the optimum stroke to play. At the beginning of their innings batters tend to be more cautious and play more defensively but as the innings progresses the batters will play more attacking strokes. The number of batters out or the remaining batters also determines the shot selection as batmen will play more attacking when there are a few batters out and more defensive as the number of batters who get out increases.

Again it is important to point out that this research focuses on the shot execution. All the above constraints are kept constant, this leads to a known ball being bowled then the shot execution is analysed. Technology may provide an effective training system for the cricketers but this alone will not help a team to win. It has been argued that the cricketer must cultivate a winning spirit, the technology will not address this and this is not considered here [12].

3 Fuzzy Sets and Cricket

According to [13] and [14], Fuzzy sets provide us with a meaningful representation of vague concepts expressed in natural languages. This idea is particularly useful in cricket. The coach/trainer needs to get across to the cricketer a clear illustration for terms of body postures such as foot forward, head up etc. There are a lot of vague terms in the sport of cricket. Head down, front foot forward and back foot on toes are a few of these. To the young cricketers, the terms can be confusing because of their inherent ambiguities. Set theory and in particular fuzzy theory seek to group these descriptions of the cricketer’s motion and define more clearly these ‘fuzzy’ terms. The aim is to tell how far from the crease (actual distance) must the front foot be before it can be considered down the pitch, for example.

Fuzzy sets and Fuzzy theory is having widespread applications in an evolving technological world. Fuzzy theory has been described as a use for screening methods [15].

In this research the cricket stroke is described using (fuzzy sets) from the moment the bowler starts the run up process until the ball is deflected from the bat and the motion has ended. This hitting motion can generally be separated into the stages of preparation, back swing, forward swing, impact and follow through [7]. Consistent with this principle, and via an analysis of this motion by the coach, this motion is divided into three time intervals namely; the waiting state, the receiving state, and the playing and follow through state. It is therefore critical for the analysis to take into account this time for the progression through these stages and thus temporal segmentation is included in the classification scheme. The waiting state describes the batter taking up his position at the crease to face the bowler. The receiving state starts when the bowler releases the ball and the batter is now moving to find the best position to play the selected shot. During the receiving state the batter seek postural cues from the bowler that may assist in perceptually anticipating the lateral displacement, the pitch (where contact is first made with the ground) and speed of the ball [16]. Here the batter decides on the best stroke to play for the particular ball being bowled. The ball
making contact on the bat, the batter’s orientation of the bat to play the stroke and the motion of the batter after the ball leaves the bat and the bat is to be returned to the crease, describes the playing and follow through states.

Included in the definition for each stroke is the ball being bowled. This can be extended to include the speed of the ball and defines the time required for the ball to travel the length of the pitch (from crease to crease), a distance of 17.68m. This variable, when added to the classification scheme, suggests that the progression in time through the stroke is not uniform for all the strokes. This means, for example, that the time required for the playing state in the cover drive is not the same as for the playing state for the hook shot.

Important for the segmentation is the start of the motion and the end of the motion. The start of the motion is referenced to the time the ball leaves the bowler’s hand (or bowling machine) and hence the waiting state will start at a time \( t_1 \), before this point and end at this point. The receiving state \( t_2 \) will be from this point onwards until the ball makes contact with the bat. Clearly this state is dependent on the ball being bowled since the length of the pitch is consistent. The height of the bowler is also initially considered but then ignored when the variation of speed for the same ball is factored into the classification. This variation can be dealt with by means of an average speed for a given ball. Notice however that this makes the overall system too rigid when dealing with moderate variations in speed. Further considerations could see the employment of a neural network to deal with these inconsistencies. The playing and following through state \( t_3 \) starts when the ball makes contact with the bat, then the ball is dispelled from the bat and ends at a time, \( T \), when the entire motion for the stroke has ended.
3.1 Fuzzy Sets Classification

Figure 2 shows graphical illustrations for the range of motion of head, feet and the bat over the four temporal states described above. This information is obtained from the description of the motion provided by the coach and coaching literature [4],[5],[6]. For head up and head down set, the angles are those that the chin would make if it were moved in the vertical plane. The head level is that angle when the chin is parallel to the ground (0°). The head right and head left are the angles that the head would make if it were moved in the vertical plane relative to the head being centre as zero degrees.

Using these descriptions we obtain fuzzy sets. This provides, for each stroke, a closer to human description of all the elements and a means for measuring them can be realized. The fuzzy sets for each state is described and hence the transition from one state to the next can be realized.

These sets are as follows;
- **Head vertical** /level, up, down/
- **Head horizontal** /centre, left, right/
- **Front foot** /forward, backward, at the crease, down the pitch, square, right, left/
- **Back foot** /forward, backward, at the crease, down the pitch, square, right, left/
- **Bat** /back lift, forward swing, right, left, forward, back, at the crease, swing right, swing left, twisted right, twisted left/

Using these sets we can classify strokes.

**Level 1 Rules (Cover Drive).**

Cover (w) = **Head straight AND Front foot at the crease AND Back foot at the crease**

Cover (r) = **Head slightly down AND Front foot slightly forward AND Front foot at the pitch AND Front foot slightly behind the crease AND Back foot slightly tipping AND Bat slight back lift.**

**Level 2 Rules (Cover Drive).**

Cover drive = cover (p) FOLLOWING cover (r) FOLLOWING cover (w)

**Level 1 Rules (Forward Defensive).**

Forward Defensive (w) = **Head straight AND Front foot at the crease AND Back foot at the crease**

Forward Defensive (r) = **Head slightly down AND Front foot slightly forward AND Front foot slightly down pitch AND Back foot slightly behind the crease AND Back foot slightly tipping AND Bat have a slight back lift.**

Forward Defensive (p) = **Head over the ball AND Front foot forward AND Front foot at the crease AND Back foot at the crease AND Back foot on toes AND Bat forward, AND Bat straight.**

**Level 2 Rules (Forward Defensive).**

Forward Defensive = Forward Defensive (p) FOLLOWING Forward Defensive (r) FOLLOWING Forward Defensive (w)

Notice that the sets described is a combination of sets. Table 1 contains a list of the definitions used in the rules. These are additional terms that the coach uses to describe the aspects of the motion.

<table>
<thead>
<tr>
<th>Derived Fuzzy Sets</th>
<th>Composition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head straight</td>
<td>Head level, head centre, head left</td>
</tr>
<tr>
<td>Head slightly down</td>
<td>Head level, head down, head centre, head left</td>
</tr>
<tr>
<td>Head over the ball</td>
<td>Head left, head down</td>
</tr>
<tr>
<td>Foot at pitch of ball</td>
<td>Foot down pitch, foot right, foot left</td>
</tr>
<tr>
<td>Back foot tipping</td>
<td>Back foot at crease, back foot on toes</td>
</tr>
<tr>
<td>Bat rotated right</td>
<td>Bat right, bat twisted right</td>
</tr>
<tr>
<td>Bat straight</td>
<td>Bat left, bat right and bat forward swing</td>
</tr>
</tbody>
</table>

Table 1 Definitions for derived fuzzy sets
4 System Implementation

To provide a detailed analysis of the stroke execution it is important that all relevant aspects of the batter’s motion be effectively captured. The following requirements influenced the choice of the motion capture system used in the research. These are:

1) The maximum displacement of the batter from the crease, in all directions, during the execution of the stroke (range and accuracy of the system)
2) The necessity for the batter to move freely and not be hindered by the components of the motion capture system.
3) Batting environment, this includes lighting required for the batter as well as possible impact of the ball (travelling at speeds of up to 140 km/h) with the system.
4) Portability of the system
5) Type of capture information required, 3D cost compared to available resources.

We used the Polhemus Fastrak System which provides information indicating six degrees of freedom, coordinates of x, y, z and orientation information in yaw pitch and roll. With acceptable errors the required range for the execution of the stroke can be achieved with this system. This motion capture system uses a wire link as a means of providing the data from the sensors. The sensors are fairly durable and with proper positioning they will be able to survive the damaging effects of the ball and they are not affected by light sources. The system is portable for use on a training pitch.

5 Conclusions and Further Work

Within this paper the need for a cricket batting technique analyser/trainer is argued. The requirements of such a system are then analysed. The use of fuzzy set theory to categorise strokes is proposed as a solution to the categorisation problem. Fuzzy sets are presented which provide, for each batting stroke, a closer to human description of all the elements. The fuzzy sets for each state is described and hence the transition from one state to the next can be realized. Two batting strokes are analysed and using the sets their rules are classified. To provide a detailed analysis of the stroke execution it is important that all relevant aspects of the batter’s motion be effectively captured. The requirements that influence the choice of the motion capture system are looked at and a system suggested. Further work is required in field trials of the proposed system, classification of other batting strokes against different types of bowling and the development of an expert system.

References: