

Fuzzy Sets and Cricket Batting

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Abstract: - In the game of cricket the bowler has benefited from improving technologies and he/she is becoming much more consistent in control and speed. However, present training systems are not a great help in preparing a batsman to face world-class bowlers. Therefore, a more efficient batting training system is needed. A system is proposed within this paper, to capture the motion of a batsman whilst playing a stroke. This is then compared to known strokes and feedback is provided which outlines how well the stroke was selected and played. Suggestions are also made as to the most efficient method for playing that particular stroke. A classification of the different batting strokes using Fuzzy Sets was carried out, based on body position and on the ball/bat position. Motion sensors currently found in Virtual Reality systems are proposed as a means of measuring the positional elements of this classification

Key-Words: - **Cricket Batting, Fuzzy Sets, Classification, Gesture Recognition**

1 Introduction

Over the past few years the flair that was once present in West Indies batting has faded and has been replaced with inconsistencies in technique. In contrast, the bowler has benefited from improving technologies and he/she is becoming much more consistent in control and speed. Present training systems are not a great help in preparing a batsman to face world-class bowlers. Therefore, a more efficient batting training system is needed.

Over the years technology has added new dimensions to sport. The Olympics has benefited greatly. Through motion analysis system the essentials to achieving proper technique in motion for various sporting events has been outlined [1]. Also numerous commercial systems have been developed for the sports of golf, bowling and baseball [2,3,4].

The Australian Cricket board (ACB) is probably the leader in the field of the use of technology in cricket [5]. In the past it has experimented with different back swing techniques and a deliberate "breaking" of the wrists in the back swing to see it's effect on bat speed. Some of the technologies that they use are: the Redlake high speed digital video system, for motion analysis the APAS system, the VICON reflective marker system, force plates, digital

handycams and software packages like "Video Expert" and "Swinger"

A system is proposed within this paper, to capture the motion of a batsman whilst playing a stroke. This is then compared to known strokes and feedback is provided which outlines how well the stroke was selected and played. Suggestions are also made as to the most efficient method for playing that particular stroke. A classification of the different batting strokes was carried out, based on body position and on the ball/bat position. Fuzzy Logic was then applied to this classification. Motion sensors currently found in Virtual Reality systems are proposed as a means of measuring the positional elements of this classification.

Below we suggest what we believe to be an appropriate classification scheme for batting strokes.

2 Classification of batting strokes

Consistent with other technologies a batting technique trainer should:

- a) analyze the motion of the batsman and
- b) suggest the most efficient way to play the correct stroke

Proper analysis first requires us to classify the strokes. We have devised a scheme where each stroke is classified based on the positioning of the body, the positioning of the bat and the flight path of the ball. To understand the terms used in this classification refer to figure 1 and figure 2. Figure 1 shows a bird eyes view of the second half of a cricket pitch (the second 11 yards) with the bowler bowling from left to right to a right-handed batsman (facing the ball with the feet position shown). The pitch is divided into sections representing the different bowling length (where the ball first make contact with the ground). Figure 2 shows how the bat orientation is described. This is based on the positioning of the bat. The angles are measured with the origin being at the shoulder of the bat. This is chosen because, for any stroke, the bat is more likely to rotate about this point than any other.

These classification criteria were decided upon for the following reasons:

Head position: Doing well at batting is largely dependent on being able to see the ball well. The position of the head determines how well the ball is seen. For a good shot the head must remain still.

Hand positions: This refers to how well the bat is gripped and how the wrists are angled to play each stroke. This largely determines the direction in which the ball will travel after it makes contact with the bat. This area is closely related to the bat orientation.

Feet position: The placing of the feet based on the pitch of the ball is an integral part of the strokes being played.

Weight distribution: Clearly this is closely related to the feet position. It is important to maintain good balance to be able to play well and the stroke selection will be influenced by the player's centre of gravity.

Mode of stroke: This describes the stroke in terms of attacking, defensive or semi-attacking. **Ball bowled:** The decision to play a particular stroke is primarily dependent on the ball being bowled. This refers to the length of the stroke (how far away from the stumps it pitches first) and the line of the stroke (how closely in line with the stump it pitches). Figure 1 outlines these concepts.

Bat orientation: How the bat is orientated is also important in describing the type of strokes. This orientation refers to the angle at which the bat makes contact with the ball and the plane through which the bat is swung (follow through).

Ball contact on bat: This is important in determining the shot as it gives an idea of the direction of travel of the ball after it makes contact

with bat, whether it will travel in the air or along the ground (the trajectory of the ball after bat contact).

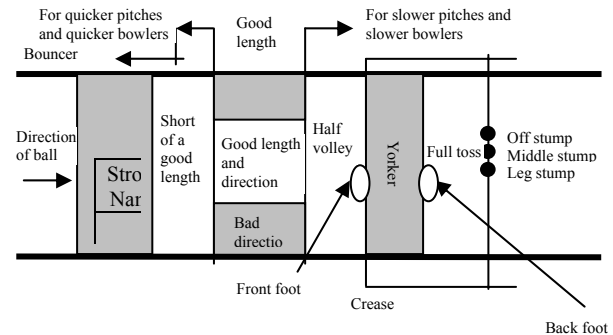


Fig. 1. The flight path for different balls that can be bowled to a right handed batsman. Only the second half of the cricket pitch is shown from Rodney Marsh, Jeffery Dujon [6].

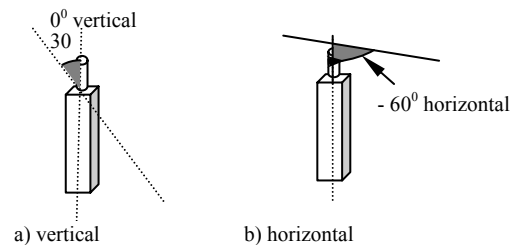


Fig. 2. Illustration of the angles used to describe the bat orientation for a right-handed batsman. Where a) shows the vertical orientation whilst b) shows the horizontal orientation.

2.1 Crisp Set Classification

We can now tabulate the information to classify the batting strokes with reference to body and limb positions. From this classification we can form crisp sets.

Stroke Name	Head Position	Hand Positions		Foot Positions		Body weight
		Top hand	Bottom hand	Front foot	Back foot	
Back foot off drive	up away from ball	angled to keep ball down	angled to keep ball down	still, maintain s balance	moves across, in line with ball	on back foot
Backward defensive	Down when bat makes contact	bat handle slightly over ball	bat handle slightly over ball	still, maintain s balance	back in line with ball	on back foot
Cover drive	Over the ball	follow through with swing	follow through with swing	30°-45° forward to pitch of ball	still, maintain s balance	on front foot
Forward defensive	Down, over the ball	wrist angled to keep ball down	relaxed to soften impact	forward to pitch of ball	still, maintain s balance	on front foot

Late cut	pointed across from the stumps	wrist angled to keep ball down	wrist angled to keep ball down	still, maintain s balance	moves across, in line with ball	on back foot
Leg glance	Over the ball	wrist rolled to deflect ball	wrist rolled to deflect ball	up off the ground	back towards the stumps	on back foot
On drive	Over the ball	follow through with swing	follow through with swing	forward to pitch of ball	still, maintain s balance	on front foot
Square cut	pointed across from the stumps	wrist angled to keep ball down	wrist angled to keep ball down	still, maintain s balance	moves across, in line with ball	on back foot
Straight drive	Over the ball	wrist angled to keep ball down	wrist angled to keep ball down	forward to pitch of ball	still, maintain s balance	on front foot
The hook	up away from ball	wrist angled to keep ball down	wrist angled to keep ball down	still, maintain s balance	back to get body in line	on back foot
The pull	up away from ball	wrist angled to keep ball down	wrist angled to keep ball down	above the ground	moved in line with off stump	on back foot
The sweep	Over the ball	wrist rolled over the ball	wrist rolled over the ball	forward in line with ball	knee bent to touch ground	on front foot

Tab. 1. Classification of cricket batting strokes based on body positions.

Stroke Name	Mode	Ball Bowled	Bat Orientation	Ball contact on Bat
Back foot off drive	Semi attacking	ball pitched between middle and leg stump	0° vertical, 0°-15° horizontal, bat straight to force ball through mid off	middle to bottom end
Backward defensive	Defensive	ball pitched to a full length	0°-30° vertical, 0° horizontal, bat raised above the ground	centre of bat
Cover drive	Attacking	half volley pitched wide of the off stump	0° vertical, 0°-45° horizontal, ball directed towards mid off	middle to bottom end
Forward defensive	Defensive	ball pitched to a full length	0°-45° vertical, 0° horizontal, bat angled to keep ball down	centre of bat
Late cut	semi attacking	ball wide of off stump and bouncing low	-90° vertical, swing through horizontal, shot played late, bat tilted down	middle to bottom end
Leg glance	semi attacking	short pitched ball, going down leg side	0° vertical, -60°-(-90°) horizontal, ball is guided behind square	middle to bottom end
On drive	Attacking	half volley pitched on or just in line with leg stump	0° vertical, -30°-(-45°) horizontal, ball angled towards mid on	middle to bottom end
Square cut	Attacking	short pitched ball wide of off stump bouncing higher than the stumps	-90° vertical, swing through horizontal, bat tilted to keep face down	middle to bottom end

Straight drive	Attacking	ball pitched to a full length	steady in horizontal plane, swing in the vertical plane	middle to bottom end
The hook	attacking	short pitched ball rising above chest height	-90° vertical, swing through horizontal, contact made at 90° horizontal	middle to bottom end
The pull	attacking	short ball, bouncing waist height in line with body	-90° vertical, swing through horizontal, contact made at 0° horizontal	bottom end
The sweep	attacking	ball pitched outside of leg stump	0°-(-60°) vertical, -45° horizontal, bat angled across on top of the ball	bottom end

Tab. 2. Classification of cricket strokes, based on ball/bat position.

2.2 Fuzzy Set Classification

Tables 1 and 2 show the information about each stroke in the form of crisp sets. We introduce fuzzy sets [7,8]. The fuzzy sets are more descriptive and show the proper association for each member of each set. This provides for each stroke a closer to human description of all the elements and now a better means for measuring them can be realized.

Of importance is the time required to play the stroke and the motion of the batsman (including bat orientation) over this period. We have divided this time into four intervals. The ready state describes the batsman taking up his position at the crease to face the bowler. The receiving state starts when the bowler releases the ball and the batsman is moving to find the best position to play the selected shot. (during this period the batsman decides on the best stroke to play for the ball bowled). The ball making contact on the bat and the batsman's orientation of the bat to play the stroke describes the playing state. Follow through describes the motion of the batsman after the ball leaves the bat and the bat is to be returned to the crease.

The fuzzy sets for each state were constructed and from these the transition from one state to the next can be realized.

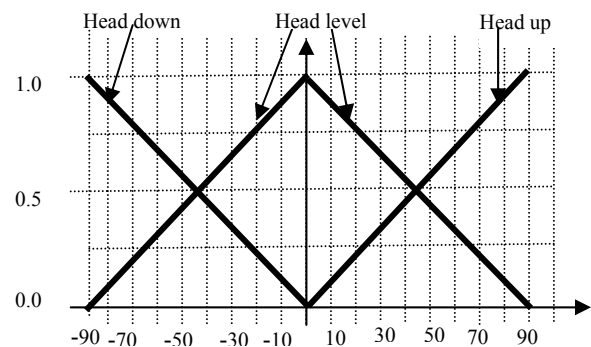


Fig. 3a vertical head sets

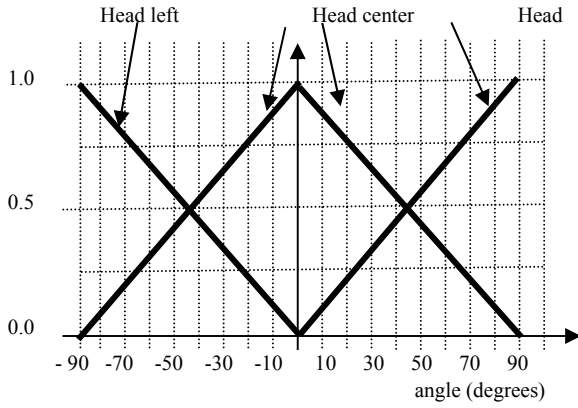


Fig. 3b horizontal head sets

For the fuzzy sets illustrated in figure 3 and others not illustrated, there are two general fuzzy membership functions. One relates to the angular variables and the other relates to length or positional variables. Generally these membership functions can be defined as:

$$A_1 = m_1\theta + c_1 \quad \text{angular sets} \quad (1)$$

$$A_2 = m_2x + c_2 \quad \text{positional sets} \quad (2)$$

Where A represents the fuzzy membership function, θ and x represent the angular and positional variables respectively. m and c are constants representing scale and offset respectively.

Equation 1 can be further expressed as:

$$A_1 = \begin{cases} m_1\theta + c_1 & \text{for } a_1 \leq \theta \leq b_1 \\ 0 & \text{otherwise} \end{cases}$$

From the graph of figure 3a (head down portion) the membership function can be constructed.

$A_1 = A_{hd}$ = membership function for the head down fuzzy set.

Thus:

$$A_{hd} = \begin{cases} m_1\theta + c_1 & \text{for } a_1 \leq \theta \leq b_1 \\ 0 & \text{otherwise} \end{cases}$$

The values of m_1 and c_1 can be calculated. Notice that m_1 , the slope of the line is expressed as:

$$m_1 = \frac{0 - 1}{0 - (-90^\circ)} = \frac{-1}{90^\circ}$$

And c_1 , the intercept on the vertical axis is;

$$c_1 = 0$$

The values of a_1 and b_1 indicate the values of θ over which the graph is defined. These are:

$$a_1 = -90^\circ \text{ and } b_1 = 0^\circ.$$

Hence equation 1 now becomes:

$$A_{hd} = \begin{cases} \frac{-\theta}{90^\circ} & \text{for } -90^\circ \leq \theta \leq 0^\circ \\ 0 & \text{otherwise} \end{cases}$$

A similar evaluation will result in the membership functions for all the other fuzzy set. As an example the membership functions for head level and front foot backwards are given below:

$$A_{hl} = \begin{cases} \frac{\theta + 90^\circ}{90^\circ} & \text{for } -90^\circ \leq \theta \leq 0^\circ \\ \frac{90^\circ - \theta}{90^\circ} & \text{for } 0^\circ \leq \theta \leq 90^\circ \\ 0 & \text{otherwise} \end{cases}$$

membership function for head level

$$A_{ffr} = \begin{cases} \frac{x}{100} & \text{for } 100 \leq x \leq 0 \\ 0 & \text{otherwise} \end{cases} \quad \dots$$

membership function for front foot forward

Notice that we have considered sets that can be considered as part of the batsman's motion.

The type of ball being bowled, although it is of critical importance to the stroke being played, is not considered. It does influence the batsman's motion but is not a part of his/her motion. The grip, although linked, to the batsman's motion is not as yet included in table 3. Force sensors are needed to be able to give accurate measurements of all the elements involved in the gripping of the bat. The current measurement system that we are using consists of positional sensors and will need modifications to include inputs from other sensors.

3 Conclusion

Within this paper we have presented work carried out to produce a fuzzy classification system for cricket batting strokes based on body and limb positions. This forms the

initial guide to the formulation and design of a full analysis system. Work continues to introduce further fuzzy classifications for the other important factors in the development of the expert system such as body weight distribution, grip, type of ball bowled etc. So far we have only looked at classifying batting strokes played against pace (fast) bowling and have not considered spin (slow) bowling. The incorporation of slow bowling into the system will require further classification of the different batting strokes played against slow bowlers.

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