BALL TRACKING IN FOOTBALL

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The aim of this study was to determine if Vicon Tracker software could be used to track a ball in a large test area. A 22 camera VICON system and Vicon Tracker software was used to track a soccer ball during soccer-specific tasks both indoor (22 m x 12 m) and outdoor (22 m x 28 m). Different ball marker setups were evaluated for accuracy and percentage data capture manipulating the number (7-9) and type (flat and half-dome) of reflective markers, as well as software settings and whether the system identified the centre of the ball. Tracker achieved greater than 90% data capture percentage using the half dome markers or nine flat marker setups, with a pre-test setup of the ball object and a 200 Hz sample rate. The ball centre was also captured by the software. Future work will examine if this system can perform in larger spaces and with multiple players in the area.

KEYWORDS:, Ball tracking, marker setup, 3-Dimensional analysis.

INTRODUCTION: The ability to track balls during small sided or full games in association football has been sought by practitioners in the sport for many years. Tracking balls in biomechanics is not a new task, having long been used in the football codes in kicking in particular (e.g. Nunome et al., 2006; Bezodis et al., 2007; Ball, 2008). Measurements have included ball speed, trajectories and impact phase characteristics. However these studies are typically performed in a space of 2-5 m with the ball tracked for only a short period of time (usually less than 1 s) while games are played in substantially larger areas and over longer time periods. The ability to be able to track the ball in larger spaces will be of benefit to analyses of small sided games and of ball tracking over larger areas which can better assist in measuring ball flight characteristics.
One of the software packages offered by Vicon is called Tracker. This software looks for a specific marker configuration within the capture area and tracks this configuration as a single object (in contrast to Nexus software which tracks single markers). This ability to track a configuration may be more successful in measuring ball movement given the difficulties of tracking single markers on a ball (difficult to maintain which marker is which given the nature of movement) and the issue of marker occlusion by a foot or when the markers are located between the ball and the ground. The aims of this study were to determine if Tracker could successfully track a soccer ball in a large are over long (1-3 min) test times during typical movements (kicking, dribbling), to identify appropriate marker types and marker numbers to optimise ball tracking and to determine if Tracker could identify the ball centre.

METHODS:
Testing was performed in the laboratory over four separate sessions. The system used 18-22 Vicon cameras (a combination of Vantage and T40 Vicon, the number depended on availability for each test session and the lab space available) to create a test space of 22 m x 12 m.

Tasks: Three soccer-specific tasks were performed in the testing space. First the ball was dribbled around the periphery of the Vicon testing space followed by a series of kicks between players with a range of speeds employed from slow to medium and hard (approximately 2 – 18 m/s). The third test was a throw-in such that the ball bounced a number of times in the test space so that the ball followed the path of a parabola while having a slow forward spin rate imparted upon it from the bounce (used to identify if the ball centre was being identified).

To determine the ability for Vicon to track different marker types, and to establish the best marker configuration, testing was performed with 7, 8 and 9 flat markers (reflective tape cut in a circle of approximate diameter 40 cm and adhered to the ball) and seven half dome markers (foam half domes with reflective tape surrounding and adhered to the ball using glue and double sided tape; Figure 1). The number of markers was chosen on advice from Vicon engineers and represents a balance between more markers to be able to be identified while mimimising the possibility that similar relationships between combinations of markers which produced ambiguity (and an error) in Tracker software that will occur with more markers.

Figure 1. Example of flat and four half-dome reflective ball markers

Two other aspects of capture were also explored. First, to determine if sample rate influenced percentage data capture, testing was conducted at both 100 Hz and 200 Hz using the dribble and kicking tasks. Second, the ball object identification was performed in two ways: live (during testing) and pre-defined (using a smaller data capture area such that all markers could be seen in the same frame).

To evaluate the position of the centre of the ball located by Tracker, a ball bounce task was performed. Mimicking a throw in, the ball was thrown such that it bounced a number of times in the test space. For each bounce, a quadratic trendline was fitted in Excel and the r-squared value and was used to indicate how closely it represented a parabola. If the location of the ball centre identified by Tracker software was not the middle of the ball, then a pattern exhibited in Figure 2 would be evident.

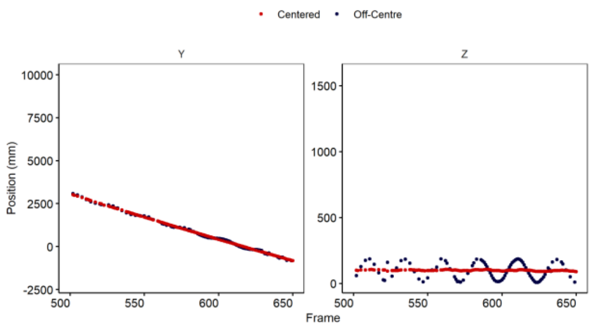

Figure 2. Example traces of Y (direction of travel) and Z (vertical) position of a ball with the centre skewed to one side (blue line), and the trace with the ball centre correctly identified (red line) whilst rolling along the ground.

RESULTS:

The half-dome marker system was best overall, with the 7-marker system performing best of the flat markers for kick tests, and 9-marker system performing best for the position data at both sample rates. Percentage capture was larger for the higher sample rate for all marker setups and conditions.

Table 1. Comparison of percentage of frames captured using different marker setups at sample rates in the lab.

	100 Hz		200 Hz	
	Dribble	**Kick**	**Dribble**	**Kick**
7 x Flat Marker	56	58	70	77
8 x Flat Marker	70	51	78	72
9 x Flat Marker	71	55	88	75
7 x Dome Marker	87	80	95	94

Developing the ball object sing a smaller test area prior to testing showed higher percentage data capture compared to the live (in-test) method (Table 2).

Table 2. Example ball capture percentage with and without pre-test ball object creation (7 flat marker setup, 100 Hz).

Test	No pre-test object (%)	Pre-test object (%)
Dribble	56	70
Kick	58	85

A total of 23 bounces were analysed with an average R^2 of 0.999 +/- 0.001. Figure 3 shows an example analysis for a bounce.

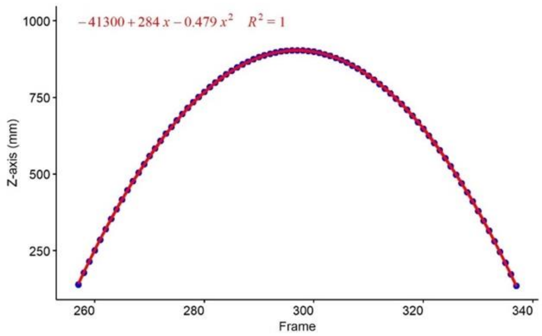

Figure 3. Example parabola analysis to determine the ball's centre during a bounce trial. The blue trace indicated the ball's true Z-axis position and red line the predicted ball trace, with the R^2 value reporting the variance between the two traces.

DISCUSSION

Tracker can track a ball in a large area with high data capture percentages. The use of a 7-marker half dome setup obtained capture percentages over 90% when the sample rate was 200 Hz. Flat markers also performed reasonably well, achieving captures above 70% at 200 Hz. This capture percentage would be reasonable for use in tactical analysis where position relative to players is being examined or where validating other systems. However more work trying to increase this percentage is still warranted as is examining where the gaps are occurring.

The use of half dome markers, had two limitations. These markers would cause the ball to bobble slightly when rolling on the ground. Further, these markers occasionally fell off under circumstances of high friction (e.g. when the ball contacted the ground at high speed after a kick). While the half dome markers will certainly provide an option for testing, limitations warrant further exploration of flat markers that avoid both of these issues.

Tracker was able to determine the ball centre with accuracy based on R^2 values close to 1 for all tests and parabolas analysed. It was noted that this might not be the case for every time the ball was marked up given it is difficult to exactly replicate marker positions (not the case in these tests). However, the software allows for the centre of the object to be changes so with appropriate optimisation software, this could be performed in cases where a parabola was not evident or lower R^2 values were obtained. The use of a parabola or a ball roll test should form a part of this (or any spherical ball testing) where the ball is being tracked over a period of time in a large space.

CONCLUSION:

Tracker software can be used to track the centre of a ball in a large test space. A 7-marker half dome setup at 200 Hz performed the best, with above 90% data capture percentage, but was limited in making the ball bobble and could fall off. Flat markers achieved above 70% and might also be used given these issues. It is recommended to perform a pre-test ball object identification in a smaller test area before data collection.

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