ANALYZING BROADCAST VIDEO FOOTAGE TO DETERMINE FOOTBALL ATHLETE KINEMATICS

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INTRODUCTION

When trying to establish the 3-dimensional kinematics of moving objects through film or video analysis, information on the positions and orientations of the cameras, focal lengths, level of panning and zooming, and scales and reference frames to calibrate the space in which the objects move are generally known. Lack of parts of this information will limit the extent to which the kinematics of the objects can be resolved.

Since 1997, Biokinetics has been studying concussion occurring from head impacts in NFL football (Newman et al, 1999). Part of this study is based on establishing the impact velocity of colliding helmeted heads as recorded by multiple broadcast cameras around the football field, and replicating the impacts in our laboratory with crash test dummies. No information on camera position, orientation, focal length, panning, or zooming was known, and a new method was developed to resolve impact velocity.

METHODS

The kinematics analysis method employs several digitized video images just before and just after impact. Broadcast quality footage was recorded at 30 Hz, but separation of each image into two fields allowed to enhance the sample frequency to 60Hz.

Football is played on a field with a well laid out grid. Close to the centre of the video image, reference lines are defined in each view using playing field references, such as yard lines and hash marks (**Figure 1**).

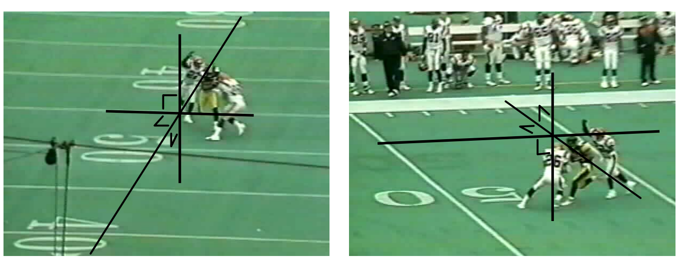

Figure 1: Two camera views of an NFL head impact incident.

A 3D-CAD package (AutoCAD) is used to establish camera angles with respect to the field. The reference lines are superimposed onto a drawing of the field. The drawing of the field is then rotated in three dimensions until the reference lines align with the field landmarks. The CAD package then provides the camera angles relative to the field as shown in **Figure 2**.

Measuring the distance in pixels between colliding heads in subsequent images in one view, scaling the pixels to a known dimension in the field of view (usually a helmet dimension) and dividing it by the time elapsed between views (1/60th second) provides the instantaneous closing velocity of the heads. Extrapolating this velocity up to the moment of impact provides the relative impact velocity in each view. Projecting the 2-D relative impact velocities of two views to the location of impact, using the camera angles established previously, provides the 3-D relative impact velocity of the colliding heads, as illustrated in **Figure 2**.

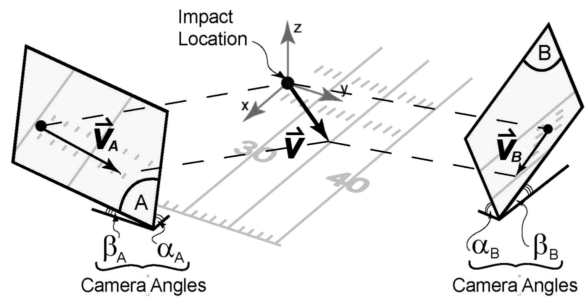

Figure 2: Principle of determining the 3-D relative impact velocity from two camera views.

DISCUSSION

The accuracy of the kinematics analysis method described above depends on many factors, such as quality of the footage, the ability to scale pixels to real dimensions, and the accuracy and experience of the operator of the CAD system. Using several staged events with helmeted subjects moving at known speeds, the accuracy of the method for the NFL study on concussion was found to be within 12% (Newman et al., 2002). The kinematics analysis was by far the largest source of errors in the complete reconstruction process of head impacts in NFL football.

Establishing the kinematics of colliding body parts and other objects is a critical step in the understanding of the mechanics involved in impact related injury. The method presented here has the potential to be used in many other sports captured on video, such as (professional) hockey, soccer, and other contact sports. It has proven to be an adequate means of providing the necessary impact velocity to reconstruct head impacts.

ACKNOWLEDGEMENT

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REFERENCES

Newman J. A. et al. (1999) *A New Biomechanical Assessment of Mild Traumatic Brain Injury, Part 1 – Methodology.* Int. Conf. on Biomechanics of Impacts (IRCOBI).

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