A MODEL-BASED IMAGE-MATCHING TECHNIQUE FOR 3D MOTION RECONSTRUCTION FROM UNCALIBRATED VIDEO SEQUENCES – APPLICATION TO ACL INJURY SITUATIONS

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INTRODUCTION

Knowledge about injury mechanisms is essential to prevent injuries. For obvious reasons, injury situations cannot be reconstructed in a lab setting. In most studies information on the mechanisms of injuries in general – and ACL injuries in particular – has been collected using questionnaires given to the injured athlete, often weeks after the injury occurred. Recall bias is an obvious problem using this approach, but another important limitation is that injuries often happen in a split second, and the athlete is not always aware of what really happened. However, in many cases video recordings exist which may provide more objective information on the injury mechanisms. Simple visual inspection of videos have been employed to extract biomechanical information from injury situations, but systematically collected and representative video samples have not been available. Although other approaches, like mathematical modelling and simulation have been undertaken, a lack of reliable kinematic information from the actual injury situations represents a significant problem.

The purpose of this project is to develop a model-based image-matching technique to reconstruct injury situations for later 3D biomechanical analyses of kinematics and kinetics. The method will subsequently be used to describe the injury mechanisms for non-contact ACL injuries in handball and freestyle skiing on a sample of systematically collected injury videos. The project may be expanded, if collaboration with research groups in the US can be established, to include an analysis of ACL injuries in typical college sports such as basketball.

METHODS

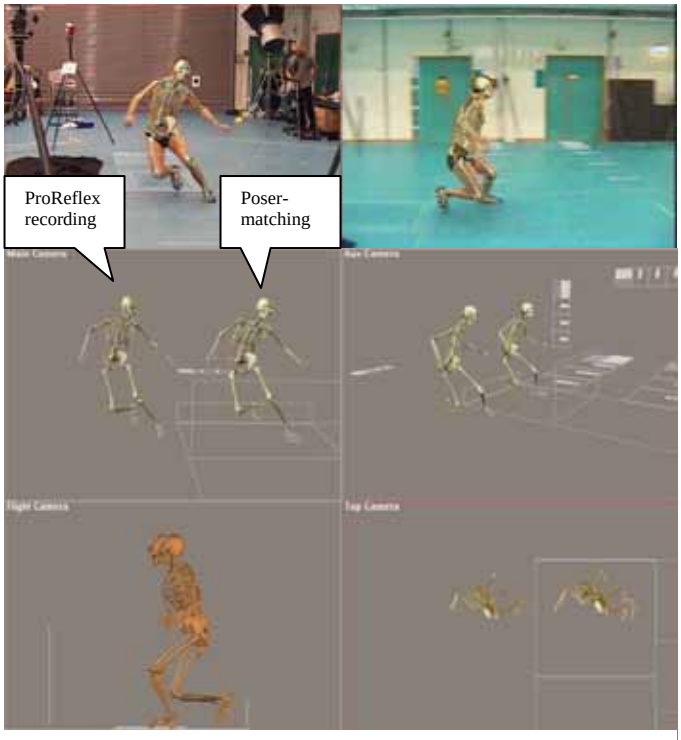

Figure 1: A Poser model matching of the video sequences, and the comparison with the recorded ProReflex motion.

We have so far collected about 40 videos of ACL injuries in European team handball where – based on simple visual inspection – the most common injury mechanisms are plant-and-cut maneuvers and landing from jumps. Additionally, the systematic collection of ACL injury videos from WC Freestyle skiing is ongoing. So far we have collected about 15 videos.

An interactive model-based image-matching method will be used for the estimation of 3D motion from one or more (manually synchronized) 2D video sequences. The commercially available 3D modeling program Poser® provides the environment for image matching. The matching procedure consists of the following steps:

- Measuring the anthropometry of the subject and building a customized computer-model (e.g. by changing segment dimensions of an existing model).
- Measuring landmarks (e.g. floor, walls, lines, objects) in the background and building a virtual environment similar to the original.

- Importing the video sequence(s) in Poser as background for the virtual environment and model.
- "Calibrating" the Poser-cameras at each time step (e.g. adjust the translation, orientation and focal length parameters to make them similar to the original), by matching the virtual environment to the background reference
- Matching the model to the background person.
- Exporting the necessary joint rotations and translations for further biomechanical analyses

RESULTS

At present, we are doing a lab validation of the method. Several trials of running and side-step cutting are recorded by three ordinary video cameras. We then use the described matching technique to reconstruct the 3D motion from respectively one, two, and finally - all three cameras.

The trials are also recorded with a 7-camera infra-red, 240Hz reflective marker based system (ProReflex, Qualisys Inc., Gothenburg, Sweden.), and two force platforms (AMTI LG6-4-1, Watertown, MA 02472, USA) that represents the "gold standard" for this validation. Preliminary results indicate that we get a reasonably good match when 2 camera views are available. When only one camera view is available, it is, however, more difficult to make a reliable matching.

The proposed method will potentially bring us a step closer to understanding the mechanisms of ACL injuries in a variety of sports, by providing kinematic information that can be used for:

- Description and classification of injury mechanisms.
- Input to different mathematical and/or cadaver simulation models.
- Other analyses based on kinematics (for instance to generate release criterions for an "intelligent" boot-binding system in alpine skiing.)

ACKNOWLEDGEMENTS

The Oslo Sports Trauma Research Center has been established at the Norwegian University of Sport & Physical Education through generous grants from the Royal Norwegian Ministry of Culture, the Norwegian Olympic Committee & Confederation of Sport, Norsk Tipping AS, and Pfizer AS.