# 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. As video sequences are often the only objective source of information from the injuries, special interest lies in utilizing video material. The purpose of this project is to develop a model-based image-matching technique to reconstruct injury situations for later 3D biomechanical analyses. The method will be used to describe the injury mechanisms for non-contact ACL injuries in sports.

**METHODS:** An interactive model-based image-matching method is used for the estimation of 3D motion from one or more (manually synchronized) 2D video sequences. The 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, starting at the pelvis.

Trials of running and side-step cutting were recorded by three ordinary video cameras. We then used the described matching technique to reconstruct the 3D motion from respectively one, two, and finally - all three cameras. A lab validation of the method was done by comparing the results from this method to the ones given by a 7-camera, infra-red, 240Hz reflective marker based system (ProReflex, Qualisys Inc.), and two AMTI force platforms.

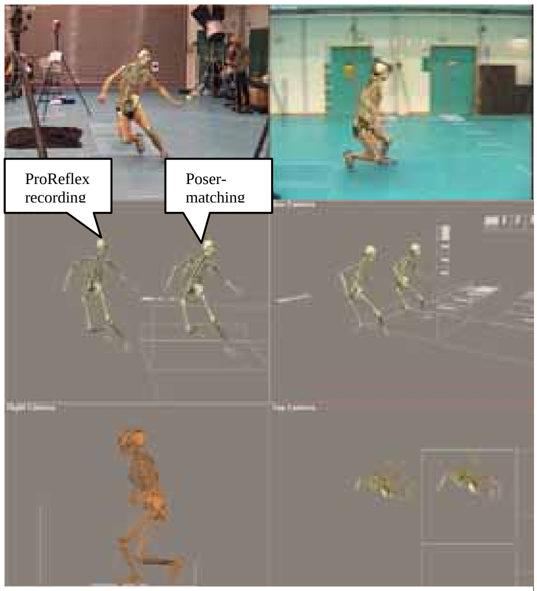

**Figure 1**: A Poser model matching of the video sequences, and the comparison with the recorded ProReflex motion.

**RESULTS:** Preliminary analyses were done for the cutting maneouvre. Table 1 below gives the range of RMS errors in joint angles for the support leg during the stance (plus 0.04s before and after ground contact) for all the seven matchings. Table 2 gives velocity and acceleration RMS and max errors for the Center Of Mass (COM).

**Table 1:** Joint angle RMS errors (Max errors in parenthesis)

| Hip Flexion (degrees) | Hip Adduction (degrees) | Hip Rotation (degrees) | Knee Flexion (degrees) | Knee Varus (degrees) | Knee Rotation (degrees) |
|---|---|---|---|---|---|
| 3-11 (6-19) | 14-16 (19-24) | 6-17 (13-26) | 5-12 (12-22) | 5-7 (8-13) | 8-13 (15-19) |

**Table 2:** Center Of Mass velocity and acceleration RMS errors (Max errors in parenthesis)

| AP Velocity (m/s) | ML Velocity (m/s) | Vertical Velocity (m/s) | AP Acceleration ($m/s^2$) | ML Acceleration ($m/s^2$) | Vert Acceleration ($m/s^2$) |
|---|---|---|---|---|---|
| 0.09-0.40 | 0.09-0.61 | 0.13-0.18 | 3.0-9.2 | 2.9-12.7 | 4.7-5.8 |
| (0.21-0.75) | (0.22-1.04) | (0.14-0.44) | (6.6-18.1) | (10.1-21.1) | (13.8-23.5) |

**DISCUSSION:** Flexion angles were quite consistent for the triple, double as well as single camera matchings. Error analyses for the individual segments showed that the major reason for the inaccuracies originated from erroneous matching of the pelvis. This lead to a shift in hip abduction of about 15 degrees for all the matchings. The femur orientation was generally better, while the tibia was best. The velocity estimates were generally good as long as the movement was not in the depth direction for the camera view. The matchings where 2 perpendicular cameras were available additionally produced good accelerations. These results indicate that inverse dynamics estimations may be feasible in situations where we have two camera views, at least for the knee.

**CONCLUSION:** The proposed method can 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 and as input for different biomechanical models.