2D/3D SSM RECONSTRUCTION METHOD BASED ON ROBUST POINT MATCHING

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Accurate reconstruction of the knee pose from two X-Ray images will allow the study pre-operative kinematics (for custom prosthesis design) and the post-operative evaluation of the intervention.

We used a SSM of the distal femur, based on 24 MRI datasets, from which the mean model and its modes of variation were defined. On the SSM, N landmarks in predefined positions were defined. The user identifies the same landmarks on two X-ray projections. Back-projecting the X-ray from the identified landmarks pixel to the corresponding source, each landmark position in the 3D space is reconstructed and the mean model pose initialized with a corresponding points registration. The silhouette of the SSM is projected on each X-ray image, which is automatically segmented in order to define the bone contours. With a Robust Point Matching algorithm based on Thin Plate Splines the projected silhouette points are deformed to better approximate the contour. For each contour point, the associated silhouette point is computed. We back-projected the ray from each contour point to the source and find on each ray the point with minimum distance to the silhouette. The cost function is the squared sum of the distances for both images. After a first optimization of the pose, we perform a shape optimization to find the correct weights for the SSM.

To evaluate our algorithm, we used two Digitally Reconstructed Radiographs (DRR) created as projections at 90° from a CT dataset. The CT based model was reconstructed and the landmarks were defined on it with a rigid registration of the SSM. In order to validate the robustness of our reconstruction method, a random uniform noise distribution (0-50 mm on each direction) was added on each landmark. The reconstruction accuracy was measured as the distance between each reconstructed landmark and the ground truth defined on the CT.

Results show that the populations of the errors for the noise levels from 0 to 30 is similar: only the population with 50 mm noise is significantly different from the results obtained with other noise levels.

We can conclude that with a noise level below 50 mm the algorithm is able to return the correct pose of the femur, while with higher noise the initial distribution of the landmarks in the 3D space prevents the correct outcome of the algorithm. The user should select the landmarks within a range of 50 mm on the 3D representation, that is half the dimension of the bounding box containing the model. We can assume that in the real case it will be more difficult to select the proper position of the landmarks, but our method proved to be robust even with misplaced landmarks.