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QUASI-AUTOMATED 3D RECONSTRUCTION OF THE LOWER LIMB COMBINING STATISTICAL SHAPE MODELING AND IMAGE PROCESSING FROM BI-PLANAR X-RAYS

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Summary: 3D reconstruction from low dose bi-planar x-rays (BPXR) has become common practice in clinical routine. The aim of this study is to partially automate the process, thus decreasing reconstruction time and increasing robustness.
As a training set 50 femurs and tibias were segmented from CT scans together with 80 BPXR reconstructions. From this data and 13 numerized landmarks, bony shapes are initialized through Gaussian process regression (GPR). This initial solution is retro-projected on both x-rays, then an automatic adjustment is performed based on image processing. A ribbon is defined along the retro-projected contours (RC) and an adapted minimal path algorithm is applied to recover a contour which sticks to the corresponding image contour. To ensure robustness, we introduced in the graph some prior costs related to the initial annotations and to the Gaussian process.
Once the vertices belonging to the RC have been paired to the detected image contours, two successive GPR are applied to deform the bones. The first one is built from the training set and enforces a probable shape, the second one is created as a Gaussian kernel and allows finer deformations. This process (detection, matching and two steps deformation) was iteratively repeated and combined with a decreasing ribbon area as a regularization process.
The proposed method has been applied to the femur and tibia parts. A preliminary evaluation has been realized on the femur comparing 20 cadaveric CT scans (1 mm resolution) from which we have simultaneously generated digital radiographs and their bony surfaces. The projected Euclidean distances between femur reconstructions and the segmented CT data were on average 1.0 mm with a RMSE of 0.8 mm. Femoral torsions errors were also assessed: the bias was lower than 0,1° with a 95% confidence interval of 4.8°. Full validation is in progress considering a large range of normal and pathological lower limbs.
Once fully validated, such a method should drastically improve 3D reconstructions from BPXR since it allows to obtain a fast and reliable reconstruction without any further manual adjustments, essential in clinical routine.