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Registration of 3D CAD model on experimental 2D projections in the framework of mask-based Sparse-View Computed Tomography

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X-ray tomographic reconstruction is a non-destructive testing tool increasingly used by manufacturers for ensuring the conformity of the produced parts. Despite a growing interest, it is struggling to establish itself in online testing applications due to acquisition times that are still too long. To reduce the number of projections while still getting good reconstruction quality, we propose to infer a so-called ‘mask’ on the volume to be reconstructed. By constraining the back-projection of the acquired radiographs only on this mask, corresponding to the voxels of the volume containing matter, iterative reconstruction algorithms, already very efficient at a low number of views compared to the traditional FDK, can better reconstruct an object, and with fewer computational resources. However, this technique requires a preliminary step: the registration of the experimental data to the a priori mask data.

In this work, we consider the CAD model of the object as the mask used to constrain the reconstruction and we propose to perform the registration step by virtually moving this 3D geometric model in a simple radiographic projection simulator until the simulated projections match our experimental projections. We use an algorithm inspired by *Iterative Inverse Perspective Matching* to register the experimental and simulated data. The algorithm includes several steps, consisting of identifying points of interest on one or more experimental radiographs. For each 3D point of the CAD model, a correspondence is established with one of the 2D points of interest of the radiographic image. Then each point P of the CAD model is projected orthogonally on the ray coming from the corresponding point of interest to form a new slightly shifted 3D point P'. When all the CAD points have been processed, it is then possible to use 3D/3D registration methods instead of 3D/2D methods, which are often less robust and more computationally extensive. To improve the algorithm performance, only the points of the convex hulls of the CAD model and the object shape in the projections are considered. This drastically reduces the number of points without affecting the accuracy of the method. The results, validated on realistic simulated and experimental data, show good accuracy for the registration step, which is overall performed in a computation time of a few seconds.

In a second step, and once the registration process has been completed, we create a mask adapted to our object using the registered CAD model, which is further processed with a morphological operator to fully enclose the real volume of the part. Only voxels included in this mask are considered as unknown, which greatly reduces the dimension of the problem to solve, especially in the case of hollow shapes. Based on the registered mask, reconstruction results obtained from simulated images are then presented from no more than a dozen of projections and show the potential of the approach that ensures the detection of inserted flaws not visible with a classical iterative approach. These results show typically the potential of such approach for on-line static systems of less than 12 views.