Computed laminography using a priori information

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Abstract
For the inspection of planar objects like printed circuit boards standard computed tomography methods like filtered back projection are inadequate. Inspection tasks which need extremely high resolutions require a high geometrical magnification and a very small X-ray tube focal spot as well as data from a full angular range of 360°. Due to the planar geometry of the object, ray penetration in longitudinal direction is often impossible or would require much higher energies than in the orthogonal direction which could increase the focal spot size to unacceptable values. Providing the necessary magnification means reducing the distance between source and object to values which could cause a collision between X-ray tube and object, thus preventing a full 360° rotation. Computed laminography is a viable alternative in these cases. Due to the reduced angular range of a laminographic scan the resulting reconstructions are prone to severe streaks and other artifacts. Standard laminographic reconstruction algorithms like tomosynthesis are unable to provide options to reduce these disrupting effects. Despite being computationally more demanding, algebraic methods like SART (Simultaneous Algebraic Reconstruction Method) are much better suited to solve this problem and are also able to incorporate a priori information about the inspected object. Although this approach is often cited in pertinent literature, it has only rarely been put to use in practice. We have studied the semi-automatic extraction of weighting factors from a voxel description of the entire object and its use to restrict and refine the subsequent reconstruction process. Especially in cases where only a limited angular coverage is available, incorporating knowledge about the object's geometry has been found to significantly increase contrast and quality.

First the necessary a priori information has to be obtained in form of a voxelized object model. This description can be extracted from existing CAD model plans, which are available for most mass produced items, or from a surface model generated from laser-scanning or other optical or tactile methods. Starting from a given voxelized model, several types of semi-automatic extraction algorithms have been developed depending on object geometry and inspection task. One of these methods is used to separate the voxel object model into areas of material and areas of air. The voxels of disjoint areas are then assigned probability values ranging from 0 (definitely no material present) to 1 (material definitely present), resulting in an a priori weighting volume. A finer division into areas of high, medium and low material probability is also possible, if the quality of the object model is not sufficient or a certain tolerance level is desired. The a priori weighting volume is then incorporated into the SART algorithm which checks for each reconstruction voxel the corresponding a priori weighting volume voxel and adapts the back projection step accordingly. This process greatly improves the reconstruction of the object's contours and increases contrast, allowing for a more dependable detection of small defects, which would have otherwise been obscured by noise and artifacts. We will give examples of both semi-automatic extraction procedures and reconstruction results using a priori weighting volumes of both measured and simulated data sets.

Keywords: Computed laminography, a priori information, algebraic reconstruction, planar objects