Abstract: Fiducial Marker Recovery and Detection From Severely Truncated Data in Navigation-assisted Spine Surgery

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Fiducial markers are commonly used in navigation-assisted minimally invasive spine surgery and they help transfer image coordinates into real-world coordinates. In practice, these markers might be located outside the field-of-view (FOV) of C-arm cone beam computed tomography (CBCT) systems. As a consequence, reconstructed markers in CBCT volumes suffer from artifacts and have distorted shapes, which sets an obstacle for navigation. In this work, we propose two fiducial marker detection methods: direct detection from distorted markers (direct method) and detection after marker recovery (recovery method) [1]. For direct detection from distorted markers in reconstructed volumes, an efficient automatic marker detection method using two neural networks and a conventional circle detection algorithm is proposed. For marker recovery, a task-specific data preparation strategy is proposed to recover markers from severely truncated data. Afterwards, a conventional marker detection algorithm is applied for position detection. The networks in both methods are trained only on simulated data and the two methods are evaluated on simulated data and real cadaver data. The direct method achieves 100% detection rates within 1 mm detection error on simulated data with normal truncation and simulated data with heavier noise, but only detect 94.6% markers in extremely severe truncation case. The recovery method detects all the markers successfully in three test data sets and around 95% markers are detected within 0.5 mm error. For real cadaver data, both methods achieve 100% marker detection rates with mean registration error below 0.2 mm. Our experiments demonstrate that the direct method is capable of detecting distorted markers accurately and the recovery method with the task-specific data preparation strategy has high robustness and generalizability on various data sets. The task-specific data preparation is able to reconstruct structures of interest outside the FOV from severely truncated data better than conventional data preparation.

References

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T. M. Deserno et al. (Hrsg.), *Bildverarbeitung für die Medizin 2023*,
Informatik aktuell, https://doi.org/10.1007/978-3-658-41657-7_4