Int J Comput Assist Radiol Surg. 2022 Mar;17(3):541-551. doi: 10.1007/s11548-021-02548-1.
Epub 2022 Jan 31.

Computational and image processing methods for analysis and automation of anatomical alignment and joint spacing in reconstructive surgery

Usamah N Chaudhary [1], Cambre N Kelly [2], Benjamin R Wesorick [2], Cameron M Reese [2], Ken Gall [3], Samuel B Adams [4], Guillermo Sapiro [5], J Matias Di Martino [5]

Affiliations
PMID: 35099684 DOI: 10.1007/s11548-021-02548-1

Abstract

Purpose: Reconstructive surgeries to treat a number of musculoskeletal conditions, from arthritis to severe trauma, involve implant placement and reconstructive planning components. Anatomically matched 3D-printed implants are becoming increasingly patient-specific; however, the preoperative planning and design process requires several hours of manual effort from highly trained engineers and clinicians. Our work mitigates this problem by proposing algorithms for the automatic re-alignment of unhealthy anatomies, leading to more efficient, affordable, and scalable treatment solutions.

Methods: Our solution combines global alignment techniques such as iterative closest points with novel joint space refinement algorithms. The latter is achieved by a low-dimensional characterization of the joint space, computed from the distribution of the distance between adjacent points in a joint.

Results: Experimental validation is presented on real clinical data from human subjects. Compared with ground truth healthy anatomies, our algorithms can reduce misalignment errors by 22% in translation and 19% in rotation for the full foot-and-ankle and 37% in translation and 39% in rotation for the hindfoot only, achieving a performance comparable to expert technicians.

Conclusion: Our methods and histogram-based metric allow for automatic and unsupervised alignment of anatomies along with techniques for global alignment of complex arrangements such as the foot-and-ankle system, a major step toward a fully automated and data-driven re-positioning, designing, and diagnosing tool.

Keywords: Automatic realignment; Joint spacing; Pre-surgical planning; Reconstructive surgery.

Related information

MedGen

LinkOut - more resources

Full Text Sources

Springer

Medical

MedlinePlus Consumer Health Information

MedlinePlus Health Information