Automatic computation of reposition parameters of fractured long bones based on CT-analysis

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Received 14 March 2003; received in revised form 14 March 2003; accepted 17 March 2003

1. Abstract

We present a new CT-based approach for estimating the relative transformations between fragments of fractured long bones for computer aided and semi-automatic bone alignment and fracture reduction in surgery.

2. Materials and methods

First of all we segment, label and reconstruct the relevant fragments of the fractured bone in the preoperative computed tomography. After that, we use a voting mechanism to compute bone shaft axis and circumference of the long bone fragments, and separate the fractured surface. This Hough-like method is based on the fact, that most of the surface normals of the superficies surface (periosteum) are nearly perpendicular to the shaft axis. The axes are an important feature for calculating an initial reposition solution (constraining 4 dof). After these processing steps, it is possible to calculate the relative transformations between corresponding fragments by using well-known surface registration techniques, like an adapted ICP-algorithm.

3. Results

We applied our approach to CT-scans of real human femur fractures as well as to plastic femur models with diverse types of simple, wedge and complex fractures. In a nutshell, our approach reaches an accuracy of about 1 ° of angular deviation in simple cases, and even for the majority of complex fractured cases, it achieves an accuracy of below 4 ° of angular deviation. Under most conditions, the translational error is far less than the transversal CT slice distance. This holds under the premise that all significant bone fragments, which connect both bone endings, yield enough ‘analysable’ surface for reposition.

4. Conclusions

It turned out that our CT-analysis-based approach for estimating the relative transformations between fragments of a fractured long bone is a very robust and accurate tool for computer-aided and semi-automatic bone alignment and fracture reduction in surgery. The method is even applicable, if the femurs of both legs are broken; methods using mirror symmetrical relations are useless in these cases. Moreover, we achieve a better reposition precision and fracture reduction by considering the whole fragment surface, than simple landmark-based methods do. The next step is to transfer the reposition parameters to a robot system, which will take over the task of exact repositioning and stable retention. Due to this, we expect better reposition results, a reduction of radiation exposure to the surgeons, and a reduction of surgery time and cost.

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doi:10.1016/S0531-5131(03)00248-6