

An Intelligent Robotic Bone Sculptor for Unicomartmental Knee Arthroplasty

Supervisors

Supervisor from NUS: Prof. Haoyong Yu, Biorobotics Lab, NUS

Supervisor from SJTU: Prof. Guoyan Zheng, Center for Image-guided Therapy and Interventions, SJTU



Unicompartmental knee arthroplasty

Problem introduction

The past thirty years witnessed the increasing popularity of unicompartmental knee arthroplasty (UKA). In the US alone, the use of UKA increased between 1998 and 2015 at an average rate of 32.5% compared with the growth of 9.4% in the rate of total knee arthroplasty (TKA). UKA is viewed as a more conservative alternative with better kinematics and functionality than TKA. Though popular, UKA is also technically more challenging, as it requires milling the diseased side of a joint precisely to prepare a bed for the appropriate implant. The milled bone must fit the implant accurately to avoid implant loosening and mis-alignment, which is difficult to achieve using conventional approaches. A study analyzing the results of 221 consecutive UKAs with conventional approaches reported an on average 6° mis-alignment.

Proposed Thesis Topic

We propose an intelligent robotic bone sculptor, which is a hand-held intelligent tool tracked by an external spatial position measurement device. The robotic bone sculptor is designed to have a small rotary blade at its tip to allow surgeons to shape bone to accept implant. The main research questions for this project are:

- 1) How to plan the surgery to define a target shape based on a patient's CT data and implant's virtual models?
- 2) How to design and control an intelligent robotic bone sculptor to make sure that only the target shape is removed while surrounding tissues and bones are safeguarded?
- 3) How to visualize the sculpting process on virtual models created from the patient's CT data in order to provide an intuitive feedback to surgeons?

Contributions

The academic contributions of this project are the following:

- 1) Development and validation of an intelligent robotic bone sculptor
- 2) A comprehensive solution supporting automatic image segmentation and modelling, pre-operative planning, intra-operative navigation and control of the robotic bone sculptor as well as visualization of the sculpting process.