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Handheld Robot for Bone Drilling Assistance

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Abstract

Computer navigation systems has provided useful visual guidance for the surgeon to deliberately locate the tools to the anatomy. However, the tool positioning process is still manually performed. Sometimes the tool positioning may cause fatigue, stress and might be of risk to patient too. In this paper we designed a special purpose handheld robot for bone drilling. Meanwhile the coordinated controller assists the surgeon to precisely and safely drill the bone safely. Two force sensors are embedded at the handle and the cutter to measure the human exerted force and bone drilling force, respectively. The velocity command was then computed by the admittance controller for the robot controller. The motion of the control handle is positioned by the surgeon, while the surgical tool driven by the robot end-effector. The coordination between the human operator and the robot was designed so that the bone drilling can be performed more effectively than only imagenavigation scenario. The drill was able to be maintained on the target trajectory with reasonable accuracy within 2 mm although the human operator has deviated the surgical tool up to 5 cm. The compensation function to guide the drill back to the planned path was very useful to prevent the drill's breakage when penetrating through the holes on the bone plate in bone drilling procedure.

1 Introduction

Introduction of computer navigation systems in orthopaedics has provided very useful visual guidance for the surgeon to deliberately locate the tools to the anatomy. However, the associated positioning process is still manually performed and thus very much relies on the surgeon's skill. Sometimes the tool positioning may cause fatigue, stress and might be of risk to patient too. For example, the surgeon drills the screw through the holes on the two sides of bone plates or nails in MIS bone fracture treatment. Sometimes the drill may deviate from the orientation of the interline of two holes unintentionally may break the drill inside the bone. Medical robots can be very helpful to remedy these cases. A hands-on surgical robot with less bulky, less costly and more user-friendly may

[*] Masterminded EasyChair and created the first stable version of this document

be very useful [1]. Among these solutions, "Acrobot" has been proposed for uni-condylar surgery [2-3]. Another hands-on robot "steady-hand" was also developed to eliminate hand's tremor for eye surgery [4].

In this paper we designed a special purpose handheld robot for bone drilling. The embedded coordinated control assists the surgeon to precisely drill the holes safely. The robot system can prevent the drill from deviating off the target trajectory, or breaking the drill inside the bone.

2 Material and Method

Figure 1 shows the overall schematic of the handheld robot system for bone drilling. The mechanical structure is simple. The robot interacts with both the human and anatomical object through the handle and the effector of the robot respectively. Two force sensors are embedded at the handle and the cutter to measure the human exerted force and bone drilling force, respectively. The velocity command was then computed by the admittance controller for the robot controller. The motion of the control handle is positioned by the surgeon, while the surgical tool driven by the robot end-effector. The coordination between the human operator and the robot was designed so that the bone drilling can be performed more effectively than only image-navigation scenario.

Figure 1: Handheld robot for bone drilling assistance in a cadaver test

3 Results

An experiment was designed to test how the robot assists bone drilling and at the same time avoids an undesirable deviation and drill breakage. Fig. 2 shows the experimental result in a cadaver test. The drill was able to be maintained on the target trajectory with reasonable accuracy within 2 mm although the human operator has deviated the surgical tool up to 5 cm. The compensation function to guide the drill back to the planned path was able to prevent the drill's breakage when penetrating through the holes on the bone plate.

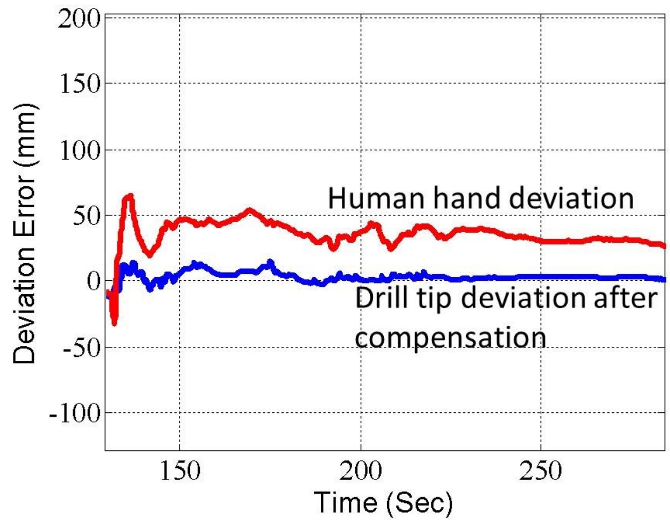

Figure 2: The deviation from the target trajectory

4 Discussion

A handheld robot with a coordinate controller has been demonstrated to intelligently assist the surgeon for precisely locate the tool in target trajectory. The power assistance from the robot simultaneously reduce the operation fatigue or errors. These two assistive functionalities of the proposed handheld robot were very beneficial for bone drilling.

References

Rodriguez y Baena F, Davies BL (2010). Robotic surgery: from autonomous systems to intelligent tools, Robotica, (p. 163-170).

Jakopec M, Harris S, Baena FR, Gomes P, Cobb J, Davies B. (2001). The first clinical application of a "hand's on" robotic knee surgery system. Comp Aid Surg, (P. 329–39).

Davies BL, Harris SJ, Baena FR, Gomes P. Jakopec M. (2004). Hands-On Robotic Surgery: Is This the Future? Medical Imaging and Augmented Reality. (P. 27-37).

Taylor RH, Jenson P, Whitcomb L, Barnes A, Kumar R, Stoianovici D, Gupta P, Wang Z, EJuan DE, Kavoussi L. (1999). A steady-hand robotic system for microsurgical augmentation. Int J Robotics Res, (P. 1201–10).

5 Disclosure

No conflict of interest.