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Electromagnetic braking-based collision protection of a novel catheter manipulator

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Abstract:

A robotically assisted catheterization system can obviously reduce the radiation exposure to the surgeon and lesson the fatigue caused by standing for long time in protective clothing. However, few designs have taken the collision protection function of a catheter manipulator into consideration. Additionally, limited research has been conducted in the damage of the clamping mechanism to the catheter. This paper presents a novel clamping mechanism based on the electromagnetic braking for a catheter manipulator which can be used in the minimally invasive surgery training system. A significant advantage is that the proposed design has the collision protection function which can realize the relative sliding between the catheter and the clamping device so as to avoid the vessel puncture, when the measured force exceeds a certain threshold. In addition, the simulation verification of this function is carried out. The results show that the clamping force of the catheter obviously decreases when the measured force increases. This clamping mechanism provides important insights into the design of safe and reliable robotic catheter manipulators incorporating effective and lossless clamping for intraoperative navigation.

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I. Introduction

A survey showed that: cardiovascular and cerebrovascular diseases have become one of the three major causes of death in human beings, which is a serious threat to human health. Even in the developed countries, cardiovascular disease remains the major cause of mortality, accounting for 34% of deaths each year [1]. For vascular tumors, thrombosis, vascular malformations, vascular contractions, vascular sclerosis, and other vascular diseases, vascular interventional surgery (VIS) is a revolutionary surgical technique, and it is an effective treatment method for the vascular diseases [2]. A surgeon manipulates a flexible catheter (a rigid hose, with a guide wire) within human vascular vessels to access a target and carry out operations under the guidance of a digital reduction shadow angiography (DSA) system. Compared with traditional surgery, VIS has many advantages: smaller incisions, quicker recovery and fewer complications. Thus, it has been widely adopted all over the world [3]. Nonetheless, the operation has obvious disadvantages: The success

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