Motion Control of Helical Robots in a Vascular Model of Carotid Artery under Ultrasound Guidance

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Introduction

Recently, engineers attempt to translate helical robots into *in vivo* applications, and this requires in-depth understanding of helical robots' behavior, such as the rotation frequency characteristics and the influence of the helical robot parameters on speed. However, several challenges invariably exist in the research of the helical robot. For helical robots, it is undoubtedly arduous to perform non-intrusive localization, because the detectable signal is limited by the size of the helical robot. Additionally, the complexity of the vascular network path will also affect the movement control of the helical robot. In this study, we first develop an *in vitro* experimental model of carotid artery, and then utilize ultrasound guidance to implement motion control of the helical robot.

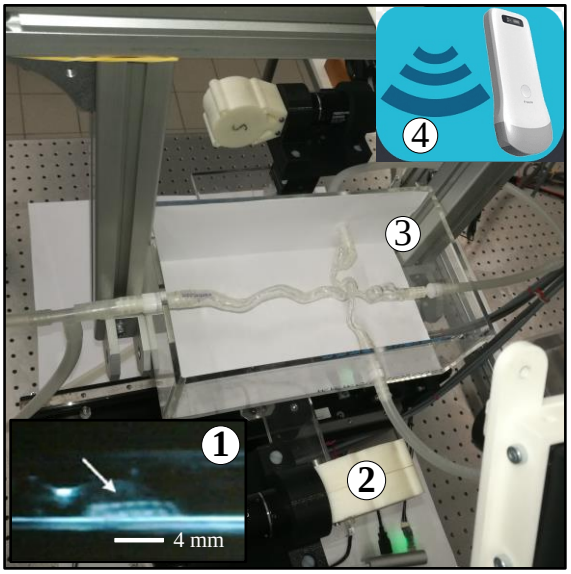

Fig 1. An ultrasound image of a helical robot①, the permanent magnet-based robotic system②, an *in vitro* experimental model③, an ultrasound image probe④.

Methods and Results

As shown in Fig 1, a permanent magnet-based robotic system, the vascular model and ultrasound system are included in our system. The vascular model of carotid artery is utilized as the main part of our *in vitro* experimental model. The location of a helical robot is determined using ultrasound images. Furthermore, we control the helical robot to motion under two synchronously rotating magnetic fields. In order to simulate the human tissue, we put the vascular model into agar gel. During the experiment, a helical robot is controlled by the permanent magnet-based robotic system under ultrasound guidance, and the motion control of the helical robot in the vascular model is realized.

Conclusion

The movement orientation of the helical robot is changed using the inverse kinematics of the magnetically-driven system and magnetic dipole-point approximation. Furthermore, we achieved the motion control of the helical robot in a three-dimensional *in vitro* vascular model based on the measured centerline of the model under the ultrasound guidance.