Chapter 32
Small Medical Robot

Makoto Nokata
Ritsumeikan University, Japan

ABSTRACT

This chapter describes the development of a small medical robot that remains in the abdominal cavity to monitor sites of medical interest and discusses robot travel operations and specifications. A long, narrow piece of ferromagnetic material was placed inside the robot, and an external magnetic field was used to set the robot in motion. The author developed a prototype robot and conducted experiments in order to verify the proposed concept and the principle of steering the robot. In vivo experiments in rabbits demonstrated that solenoids produce sufficient magnetic force to enable the robot to travel through the abdominal cavity, verifying the motion principles. The experiments also confirmed the appropriate shape of the robot, and friction between the robot and the organs and abdominal wall was measured. A modified prototype of the robot was then used to conduct clinical experiments in the rabbit model; a surgeon operated the XYZ axis stages in order to adjust the position of the subject for the experiment and moved the robot to the liver. Robot travel from the insertion point to the liver was verified on X-rays. The long distance was possible due to the improved shape and the use of accurate magnetic field imaging.

INTRODUCTION

An endoscope is a flexible tube used to examine the interior of the human gastrointestinal tract; it is inserted via the mouth or anus and manually pushed into the organ to be examined. In contrast, a capsule endoscope (Figure 1) is swallowed by a patient and naturally exits the body within eight hours (Moglia et al., 2009).

DOI: 10.4018/978-1-4666-4607-0.ch032

Another type of capsule endoscope requires a permanent magnet mounted inside it, and the capsule moves when a rotational magnetic field is applied (Ishiyama a et al., 2001; Chib et al., 2005). M. Shikanai et al. developed a robotic endoscope that consists of front and rear bodies with bidirectional rotational helical fins (Shikanai, 2009). A DC motor connects the front and rear, and clockwise rotation of the front body and anticlockwise rotation of the rear body propel the

Figure 1. Capsule endoscope "Sayaka," ©RF SYSTEM lab

robot through the intestines. These capsule-type robots require power supply wires and a permanent magnet. A potential problem with this design is that rotational drive could cause engulfment.

Medical doctors and researchers are now working together to develop a novel capsule-type medical robot, the concept of which is shown in Figure 2. The robot remains in the abdominal cavity in order to monitor sites of medical interest, and data is captured through travel, surveillance, manipulation, and communication operations. The project team is responsible for developing three components of the device: the internal computer hardware and software technologies for steering control, micro-sensing and manipulation.

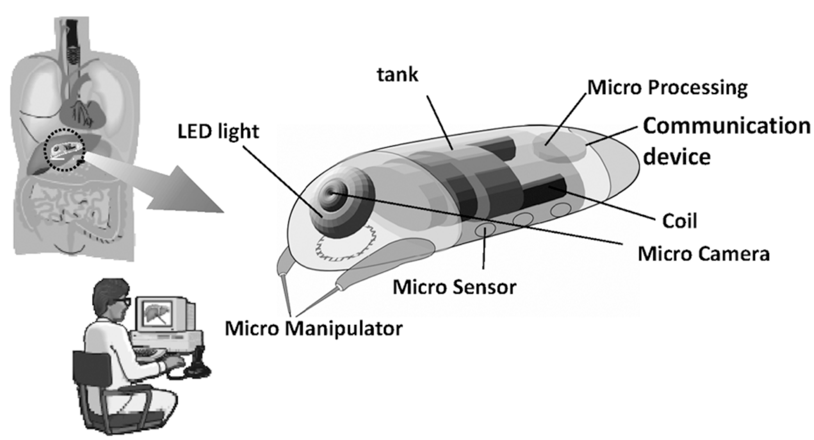
This chapter focuses on my research, which is the steering control technology for the capsule-type medical robot. Section II discusses actuators suitable for the internal driving mechanism and robot operation and specifications. Section III describes robot movement experiments conducted in a living organism for the purpose of verifying our proposed principle of robot travel. Section IV presents the results of a modified clinical prototype, and Section V discusses the conclusions of this project.

MEDICAL ROBOT OPERATION

In discussing actuators suitable for internal robot operation, the first question is whether or not robots should have actuators.

In the case that an internal robot has actuators such as a rotation motor (Rentschler et al., 2007), a shape memory alloy actuator (Haga et al., 2004; Ikuta et al., 1988), a pneumatic actuator (Carrozza et al., 2003) or an impact drive actuator (Ikuta et al., 1994) to initiate travel, the drive motor is powered by electromagnetic induction and the

Figure 2. Concept of a new capsule type medical robot in the abdominal cavity



Related Content