Study of Design Method for Surgical Robot
Using Surgeon’s Operation Manner

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Abstract. Recent design methods for surgical robots suffer from an inherent
problem. In these methods, the surgeon’s operation manner is not considered
when designing the robotic mechanism. As such, it is possible that a non-user-
friendly robot is developed for surgeons to operate. To solve this problem, we
developed a system that takes into consideration the surgeon’s operation man-
er during the design phase of the robot. Using this system, we can operate a
simulated robot with any mechanisms and can search a mechanism that is user-
friendly in terms of the surgeon’s operation manner. In the experiments, we
investigated the need for considering the surgeon’s operation manner when de-
signing a surgical robot. The results clearly show there is indeed such a need.

Keywords: Surgical robot, Design method, Surgical simulator.

1 Introduction

1.1 Background

Minimally invasive surgical techniques are continually being developed to reduce the
invasiveness of various surgical procedures. Beginning in the 1990s, the development
of new technologies, including advanced laparoscopes, clip applicators, and energy
sources for laparoscopy, provided a period of rapid development in minimally inva-
sive surgery [1]. In recent years, research and development of the technology, such as
surgical robots and navigation systems, have been ongoing. The expectations of sur-
gery performed by minimally invasive surgical robots have increased, and research
and development of surgical robots have advanced in many fields [2-3].

Laparoscopy and other minimally invasive surgeries successfully reduce patients’
postoperative pain, complications, and hospitalization time, and improve cosmetics.
Most existing robotic surgical systems have been designed for minimally invasive
laparoscopic procedures [4]. For example, Intuitive Surgical Inc. supplies the com-
mercial da Vinci system [5-6], while Ikuta developed a surgical robot with a wide
range of movement [7]. Minor created a surgical robot with excellent stiffness by
incorporating gear-links [8].
1.2 Problems

In recent years, many kinds of surgical robots have been developed to improve performance, including accuracy, moving range, and stiffness, through changes in the mechanisms. Nevertheless, there is an inherent problem in the design methods for surgical robots, that is, a lack of consideration for the surgeon’s operation manner during the design of the robotic mechanism, because changing the robotic mechanism influences the ease of operation. In addition, surgeons cannot judge how easy or hard it is to operate a robot until the robot has been fully created. Therefore, we could end up developing a non-user-friendly robot for the surgeon to operate unless we consider the surgeon’s operation manner when designing the robotic mechanism. This is a major problem in the development of high performance surgical robots.

In current design methods for surgical robots, the problem exists that the user-friendliness of the surgeon’s operation manner cannot be revealed until completion of the robot. To solve this problem, there is a need to identify the surgeon’s operation manner before actually designing the robot and to reflect this operation manner in the robot’s mechanisms (Fig. 1). If we consider a surgeon’s operation manner during the design phase of the robot, there is a greater possibility of being able to design a robot that is user-friendly in terms of the surgeon’s operation manner.

1.3 Objectives

In this research, to efficiently develop a surgical robot that is user-friendly in terms of a surgeon’s operation manner, we construct a system to identify the manner to operate a surgical robot during the robot’s design phase. The system implements two functions: 1) a master manipulator that measures the operation manner of a surgeon (operator), and 2) a slave simulator whose mechanical parameter can be freely set.

Fig. 1. Proposed design method of a surgical robot