Chapter 12
Applications of Robots in Surgery

Siamak Najarian
Amirkabir University of Technology, Iran

Elnaz Afshari
Amirkabir University of Technology, Iran

ABSTRACT

The science of robotics began as a form of entertainment and has evolved into a technology that used in various fields of computers, automotives, entertainment, ocean/space exploration, and medicine. In medicine and more specifically surgery, robotic technology has become a valuable surgical alternative to provide the new methods of surgery with the advantages of traditional open surgery approaches. In this chapter we discuss minimally invasive surgery or MIS and robotic surgery and introduce different robotic surgery systems and technologies in the world. To do this, firstly we present a brief history of robotics and its applications in different medical fields such as rehabilitation, surgery, various diagnostic stages, medical and surgical training, etc. Then we talk about surgery and different methods of it using a chronological approach. At the end we introduce different minimally invasive surgery approaches and explain robotic surgery systems and technologies thoroughly.

INTRODUCTION

The word robot, from the Czech word robota that means simply 'forced labor', was introduced for the first time by the Czech writer Karel Capek (1920) in his play Rossum's Universal Robots. He describes a plot in which man creates a robot, which initially provides benefits, but in the end produces despair in the form of unemployment and social unrest. It is also interesting to know that one of the first robots developed was by Leonardo Da Vinci (1495); a mechanical armored knight that was used to amuse royalty (Dharia & Falcone, 2005). According to the Robot Institute of America, a robot is a reprogrammable, multifunctional manipulator designed to move material, parts, tools, or specialized devices through various programmed motions for the performance of a variety of tasks (Speich & Rosen, 2004). Although the first applications of robotics were in mathematics, computers, and

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industry, today robotic technologies are used in space and ocean exploration, medical, military and police tasks and entertainment. In this regard, one of the most important applications of robotics is in medicine (Burdea, 1996; Cepolina & Michelina, 2004). Robots and robotic systems can be used to replace missing limbs, perform delicate surgical procedures, deliver neurorehabilitation therapy to stroke patients, teach children with learning disabilities, and perform a growing number of other health related tasks. Surgery and operating rooms are one of the crucial locations that robots have influenced (Giulianotti *et al*, 2003; Camarillo *et al*, 2004; Hockstein *et al*, 2007). The traditional open surgery approach is an efficient method of surgery that can be useful in different surgeries even today. In this method large incisions enable surgeons to see and manipulate the pathological tissue directly. The significant damage done to organs in the surgical path causes pain to the patient, entails long recovery time, and causes complications due to surgical trauma. In contrast with this old approach, minimally invasive surgery (MIS) or minimally access surgery is a new method for surgery, the goal of which is to prevent unnecessary trauma by reducing the size of incisions to a few centimeters or less. The benefits of reduced trauma, less pain and shorter recovery time, make MIS the technique of choice of many surgeons around the world (Mack, 2001; Melzer *et al*, 1993; Deml *et al*, 2005). Robotic surgery is one of the methods of minimally invasive surgery that refers to the application of computer-assisted robotic technologies to enhance the surgeon's ability to carry out various surgical procedures (Marescaux & Rubino, 2005; Cadiere *et al*, 2001). The robots used in surgery should ideally be part of computer-integrated surgery systems. The robot is just one element of a larger system designed to assist a surgeon in performing a surgical procedure. In fact, the robots are used to improve the outcome of operations, so they must have advantages above humans will they be successful for their operative task (Morris, 2005). Here, we present a brief history of robotics and its applications in medicine especially in surgery. Then we will discuss robotic surgery and introduce different surgical robotic systems and technologies.

1. BACKGROUND

The robotic history may be referred back to 1801, when Joseph Jacquard invented a textile machine which was operated by punch cards. The machine was called a programmable loom and went into mass production. Then, in 1892, Seward Babbitt in the United States designed a motorized crane with gripper to remove ingots from a furnace (Can Dede *et al*, 2005). The robotic developments had come to a new stage in the 20th century. The first reference to the word robot appears in 1920 in a play opening in London. From this beginning the concept of a robot takes hold (Challacombe *et al*, 2006). In 1938, the two Americans, Willard Pollard and Harold Roselund designed a programmable paint-spraying mechanism for the DeVilbiss Company. 1940 was the emphasis point in robotic history. In these years, Asimov elucidated the role of robotics through short stories; however, it was his three laws of robotics that received popular acclaim. The three laws state (1) A robot may not injure a human being, or through inaction allow a human being to come to harm (2) A robot must obey the orders given it by human beings except where such orders would conflict with First Law and (3) A robot must protect its own existence as long as such protection does not conflict with the First or Second Law (Dharia & Falcone, 2005). After that in 1948 Norbert Wiener, a professor at M.I.T., published Cybernetics, a book which describes the concept of communications and control in electronic, mechanical, and biological systems (Triclot, 2006). The first successful commercial implementation of process robotics was in the U.S. automobile industry in 1962. This industrial robot was named "Unimate" developed by George C. Devol and Joseph F. Engelberger, which was