International Journal of Research in Advent Technology, Vol.3, No.9, September 2015
E-ISSN: 2321-9637
Available online at www.ijrat.org

Advancement in the Field of Robotics in Medical Industry: A Theoretical Review

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Abstract: Over the past 20 years, robotic assisted surgery has emerged as a promising tool. This article reviews the miniaturization of robotic devices from macro to nano level. Medical robotics are basically classified and used in rehabilitation, surgery, medical training, prosthetics and other applications. Moreover, it provides benefits of minimally invasive surgery and the idea of medical robotic has become a very interesting topic for various researchers. In this article we have focused mainly how robots are used in surgical aspects.

Keywords: Surgical Robots, Nanorobots, Microrobots, Medical Surgery

1. INTRODUCTION

The field of robotics in medical industry is an extensive and useful, yet partially unexplored area. Since the last decade the extension and discovery of robots in every field is growing from the grass root level to the macro level. Robotics is a boom in medical industry since its application is in every aspect. The emergence and robotic technology has allowed surgeon's once again to achieve that and annotating their abilities often beyond what is normally possible. This article reviews the scenario of the robotics in the medical industry by analyzing the history, present and future prospective.

2. EVOLUTION OF ROBOTICS

A Robot can be termed asa machine that senses, thinks, and acts[1].Robot word was first introduced by KarelCaprk in 1920[2].

Table 1- History of Robotics in Medical Application

Serial No.	Robotic in Surgery	Description	Reference No.
1.	The first surgery using robot was performed in 1985	An industrial robot was modified to hold fixture next to patient's head so drills and biopsy needles could be inserted at a desired location for neurosurgery.	[3]
2.	PROBOT	In 1991, Davis et al. used arobotic arm coupled with a stereotactic frame to perform a transurethral resection of prostate. First active robot used in assisting surgeries to automatically remove soft tissue from a patient	[4]
3.	ROBODOC (Integrated surgical systems , Sacramento CA)	First commercially available robotic system, which was fit for implants while eliminating femoral fractures, the device was associated with greater blood loss. But was not commercialized as it didn't get FDA approval.	[5]

4.	AESOP(Automated Endoscopic System For Optimal Positioning)	A robotic arm controlled by the surgeon to manipulate an endoscopic camera, this eliminated the need for a camera holding assistant. In it the robotic arm was either controlled manually or remotely through hand or foot switch, but now it can also be controlled through voice	[6]
5.	ZEUS	AESOP was fitted with two additional arms controlled by a surgical workstation. In zeus the surgeon was made to sit in a chair along with a video monitor and the arms were controlled by the surgeon. Zeus was a telerobot , which can be used to perform long distance surgery using SOCRATES. SOCRATES was a surgical telecollaboration system that links remote surgeon with their colleagues in the operation theatre.	[7]

3. EMERGING TRENDS IN MEDICAL APPLICATIONS

Intuitive Surgical, Inc. in 1997 developed the telerobotic system known as the da Vinci surgical system, which can be used for many surgical operations such as general surgery,urology, cardio thoracic surgery, pediatric surgery. In 2000, it got approval from FDA which exploded its uses in surgery. Currently 460 systems are installed worldwide out of which 350 are in United States of America. It is not a fully automatic robot rather a computer assisted surgery at its best.

3.1 da Vinci Overview

It consist of following parts [8,9]

- Surgeon Console: It is controlled by the surgeon.It also consists of image processing centre which generates a magnified three dimensional image in the monitor.
- Surgical cart: Itconsists of three arms which perform the procedure, along with dual light source.
- Vision System: The surgeon hand eye axis is arranged such that it gets the illusion of directly operating the patient through incision while seating comfortably.
- Foot Control System: It is used to operate electrocautery.
- Master Control Grips:Itdrives the robotic arm at the patient's side. The arms of the da Vinci are made such that they can copy the movement of the hand, fingers and the wrist.

This system provides the surgeon with following features:

- An intuitive translation of the instrument handles to the tip movement, thus eliminating the effect of mirror image.
- Scaling

Fig 1. The da Vinci robotic surgical system [9]

- Tremor Filtering
- Co-axial alignment of the eyes, hand and the tooltip image.
- An internal articulated endoscopic wrist providing an additional three degrees of freedom[10]

Table 2- Current Application of da Vinci system

S No.	Field of Surgery	Description	References
1.	Cardiac surgery	Designed for performing closed chest coronary artery bypass grafting.	[11]
2.	General surgery	Laparoscopic procedure including cholesystectomy, splentectomy, small and large bowel resection, bariatric surgery,pancreatectomy.	[12]
3.	Urology	Nephrectomy, adrenalectomy	[13]
4.	Gynecology	In reversal of tubal ligation using a platform of robot.	[14,15]

Improved visualization, increased dexterity, restored proper hand eye co-ordination, system offer 6-12 times more magnification, higher accuracy, higher throughput, improved performance, enhanced diagnostic, mechanical power of the system greatly assist in surgery of the morbidly obese by overcoming the often troublesome abdominal wall stiffness that makes precise desection with conventional laproscopy in these patient difficult, [14] are the advantages of da Vinci.

4. FUTURE ASPECTS

The future applications of robotic technology will continue to provide advances in these and other areas of medical industry. Similarly in the medical industry the robots are being miniaturized to perform various bacterium. Now as the direction and flow can be controlled these robots can be used to deliver the drug directly to the concerned target, which means the treatment would be more specific. Future Challenges for Nano robotics includes assembly of a fully functional nano robot, Closed loop control and guidance at nano scale, Wireless communication and data transfer, Powergeneratio n, Accurate modeling applications inside the body directly.Micro system potentially has many advantages in micro and nano task that are beyond the limits of human manipulation. There are several advantages of these micro system in handling small parts, it also include speed accuracy and gentleness. Also surgery and drug delivery could be performed easily without any incision. [11]

Nano and Microrobots

Nano and microrobots have comparable dimension with those of biological cells and have remarkable applications in medical industries. The prime application of nanorobots and microrobots is the delivery of the drugs directly to the target using functionalized nanovectors which is very helpful in the case of cancer. Bradley Nelson from US is building robots of the size of nano and micrometers. The idea of placing autonomous self powered nanorobots inside us might seem a bit odd but actually the human body already teams with such nano device. For example more than forty trillion single celled microbes swim across our colon.[16]Micro robots are just visible with bare eyes and the nanorobots only be followed under the microscope. These microrobots draws inspiration from the drive and control system of the bacteria (E.Coli) which have an advantage of developed techniques to move with minimum energy. Thebacteria propel itself by a small corkscrew tail called flagellum [17]. A similar technique was used for propelling the robots, by recreating the spiral shaped flagella of the E.coli.For this they used semiconductor as this is the best way to control the manufacturing on a nano meter scale.Avapour deposition of magnetic nickel of ultra-thin layer on the spiral was done, which was 25-60 nanometers in length-to make the artificial flagella rotate through a magnetic field

The direction and intensity of the robot can be controlled by the magnetic field.Nano robot swims as soon as the spiral starts spinning same as the E.coli

at nanoscale, going smaller and smaller and smaller(100nm).

5. CONCLUSION

This paper reviewed a number of robotic technologies that are or will be further used in medical industry .The miniaturization of electronic components from the dimensions of inches to

microns is a revolution in this field .Robotics in medical industry requires a combined knowledge of different streams of engineering and medical background.And the future aspects seem to be very promising and will improve quality in healthcare service.

REFERENCES

[1] George A. Bekey, Autonomous Robots:From Biological Inspiration to Implementation and Control,MIT Press,2005
[2] Jackrit Suthakorn,Robotics in Medical Applications, Applied Research Laboratories of Biomedical and Robotics Technology(BART LABS),Isbme 2004
[3] Kwoh YS, Hou J., Jonckheere, E.A. and Hyalls, S. A robot with improved absolute positioning accuracy for CT guided stereotactic brain surgery,IEEE Trans Biomed Engng,1988;35(2);153-61
[4] Davies B. A review of robotics in surgery.Proc Inst Mech Eng [H] 2000;214(1);129-40.
[5] Barger WL, Bauer A, Borner M. ,Primary and revision total hip replacement using the Robodoc system,Clin Orthop Relat Res,1998(354);82-91
[6] Jacobs LK,Shayani V, Sackier JM. Determination of the learning curve of the AESOP,Surg Endose,1997;11;(54-5).
[7] Isgro F, Kiessling A-H, Blome M, Lehman A, Kumle B,Saggau W. Robotic surgery using zeus microwrist technology: the next generation.Osp Ital Chir, 2001;7;373-8
[8] Lobontiu A. The da Vinci surgical system performing computer enhanced surgery.Osp Ital Chir 2001;7;367-72
[9] Hashizume M, Konishi K, Tsutsumi N, Yamaguchi S, Shimabukuro R. A new era of robotic surgery assisted by a computer-enhanced surgical system,Surgery,2002;131(1 Suppl);S330-3
[10] Makoto Hashizume, Kouji Tsugawa,Robotic surgery and Cancer; the Present State, Problems and Future Vision,Department of disaster and emergency medicine, Graduate School of Medical Sciences,Kyushu University,Japan,2004
[11] Justin M.Albani,The Role of Robotics in Surgery:A Review,Missouri Medicine,2007,Vol 104,No. 2,166-172
[12] Himpens J, Lema G, Cadiere GB. Telesurgical laparoscopic cholecystectomy.Surg Endosc,1998;12(8);1091
[13] Schuessler WW, Grune MT, Tecuanhuey LV, Preminger GM, Laparoscopic dismembered pyeloplasy,J Urol,1993
[14] FalconeT, Goldberg JM, Robotic surgery,Clin Obstet Gynecol,2003;46(1);37-43.
[15] Degueldre M, Vandromme J, Huong PT, Cadiere GB. Robotically assisted laparoscopic microsurgical tubal reanastomosis:a feasibility study,Fertile Steril,2000;74(5),1020-3
[16] Samuel Schlafli,Nanorobots Join Fight Against Cancer, Globe(ETH,Zurich), Vol.4, Dec2013