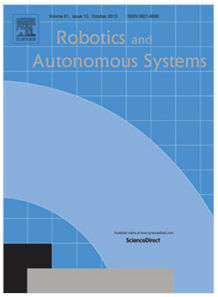
Accepted Manuscript



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PII: S0921-8890(17)30457-8
DOI: https://doi.org/10.1016/j.robot.2018.08.008
Reference: ROBOT 3070

To appear in: *Robotics and Autonomous Systems*

Received date : 3 July 2017
Revised date : 30 May 2018
Accepted date : 20 August 2018

Please cite this article as: M.S. Qureshi, P. Swarnkar, S. Gupta, A supervisory on-line tuned fuzzy logic based sliding mode control for robotics: An application to surgical robots, *Robotics and Autonomous Systems* (2018), https://doi.org/10.1016/j.robot.2018.08.008

A Supervisory On-line tuned Fuzzy Logic based Sliding Mode Control for Robotics: An Application to Surgical Robots

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Abstract— **Ever since digital technology entered in the operating theatre (OT) surgery has moved out through one of the big transformation on account of medical world and now we are foreseeing the era of digital OT. Robotic assisted surgery (RAS) is a way of technological development in the medical environment that uses robotic structure to assist in surgical measures. RAS was designed to beat the limitations of Minimal Invasive Surgery (MIS) and to improve the ability of medical doctor during surgery. The paper depicts the control methodology for surgical robots based on the combination of fuzzy logic control (FLC) with sliding mode control (SMC). The appreciable features of SMC like simplicity in design and high degree of robustness motivate researchers to employ this methodology in robotics. Nevertheless, the destructive chattering phenomenon is circumvented by espousing FLC in SMC. Additionally, the output gain of fuzzy sliding mode control (FSMC) is online tuned by a supervisory fuzzy logic control (SFLC), which results in chattering diminution. System stability is investigated using Lyapunov theorem. All numerical simulations have been carried out using MATLAB tool for 2 DOF surgical robot manipulator formulated for high speed trajectory tracking and for the typical condition during surgery. Moreover, the performance has been validated in real-time using Opal-RT Lab simulator show the efficacy of the proposed methodology. The simulation as well as real time digital simulator (OP-4500) results of FSMC and supervisory fuzzy logic based sliding mode control (SFSMC) are compared with the conventional SMC which represents the improvement of control law for attainment of optimized results by rejecting perturbations and achieving the desired system performance within a specific band of operation.**

***Index Terms*— Sliding Mode Control (SMC), Fuzzy Sliding Mode Control (FSMC), Supervisory Fuzzy Sliding Mode Control (SFSMC), Surgical Robot, Robotic Assisted Surgery.**

1. Introduction

Robotics in medical is directly related to human health. The use of robotics in medical is getting popular day by day as it has various advantages in medical field. Robot assisted surgery (RAS) has turn out to be a burgeoning area in last few years. Integration of robots in clinical room replaces the conventional surgical course of action by minimally invasive surgery (MIS) with the assistance of robotic assisted surgery (RAS). Combination of RAS with MIS results in advantages like reduced recovery time, reduced discomfort of patient and lessens post surgery effects [1]. In the span of 1970's National Aeronautics and Space Administration (NASA) were firstly initiated tele-robotics for surgery for various purposes like supporting manipulators and assisting devices. The aim of this project was to offer the medical assistance for astronauts [2].

Surgical robots are fetching the principal paradigm budge in which human lives are saved. Surgical robots assist surgeons to carry out surgeries with nominal incision, utmost precision and austerely deep incursions within a human body. Medical robotics furthermore comprises tele-robots that are remotely controlled, and come into action even where the surgeon is not physically present. Robotic assisted surgery also comprises of nano-bots, which can be gulp like capsule or instilled into blood stream [3]. Da-vinci surgical system, AESOP (Automated Endoscopic System for Optimal Positioning) and Viky are the some successful implementation in robotic assisted surgery. All these medical instruments are based on robot technology which is assisting surgeons in many surgeries [1-3]. A layout of the developing stages of robotics in medical is shown in Fig.1.