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CONTROLLING OF SURGICAL ROBOTICS PLATFORM FOR ENDOSCOPIC USING FUZZY LOGIC CONTROLLER

Ragu PJ*1, Swathi Sri R*2

*1,2Department of Biomedical Engineering, KSR Institute for Engg and Tech, Tiruchengode, Tamil Nadu, India.

ABSTRACT

In World-wide Colorectal Cancer is a most important morbidly portion occupying all the cancer types and the resection of the affected zone is the acknowledged appropriate alternative in oncological. Minimally Invasive Surgery (MIS) based on laparoscopy is accepted due to its shorter hospital stay and better aesthetic outcomes. The slope complex of the patient due to constraints of the robotic platform along with the risk of metastases at the port site has paved the way towards the developing of new robotics surgical tools for method of endoscopic like Endoscopic Submucosal Dissection (ESD) or Endoscopic Mucosal Resection (EMR), which have proven efficiency in the resection of cancerous tissues of all minimizing and reduced in invasiveness presented on MIS. The control system to be design of a novel miniaturized Robotic system for Endoscopic Dissection of gastrointestinal neoplasm by employing two types of commercial haptic interfaces (or) devices, where each one can be commanded to one of the two surgical arms, which are cautery arm and grabbing arm, of the detachable miniaturized robotics. The control strategy is based on a Master/Slave pattern, which is frequently used in Tele-operated systems, and it's composed of three units. The first one, developed in C Programming, this handles the haptic interfaces (or) devices that are guidance type and gathers the movement executed by the operator. The second one of process is this certain information and incorporating security loops to maintain a safe environment, then command the third one, which is composed by three DC motors that are integrated with the inside of robotics, that are handling with the cautery arm, and another three DC motors are kept in outside of the robotics and that are connected with cable systems, where each of these motors are manage with one degree of freedom of the grabbing tools. A gain scheduling PID algorithm, developed in Matlab and simulated with in Simulink based fuzzy logic control to enhance the adaptation to nonlinear aiming to improve the PI controller in the drivers (EPOS2 50/5) of the DC motors.

Keywords: Minimally Invasive Surgery, Haptic Interfaces (Or) Device, Fuzzy Logic Control, PI Control.

I. INTRODUCTION

The gastrointestinal interventions are complex due to the anatomical intricate shape and complicated access points the gastrointestinal tract presents. In World-wide Colorectal Cancer is a most important morbidity portion occupying all the cancer types and the resection of the affected zone? In Past, the open surgery was adopted in the resection of affected zone in the gastrointestinal tract was performed. The Drawbacks are risk of morbidity and infection for patients. In new methods reduce recovery time of patients, invasiveness is lower, the decline of all type of cancer recurrence, and improvement of surgical. Robotic surgical systems have been developed throughout the years, to increase dexterity along with the enabling simulation to enhancing the expertise or surgeons. The master/slave architecture is widely spread configuration when deals with the Tele-operated surgical systems. The design and consideration for reliability, safety and human robotic device (or) interfaces are important, and this responsibility is given out to implementation an accurate control systems. The PI controller has been implementing in Tele-operated surgical platform to be regulate with the velocity and angle positioning of the manipulators. The performance decline significantly and it can even lead to instability, if the motion is fast. Moreover PI controller cannot difficult with systems that fluctuate throughout time. The gain scheduling PI algorithms based on fuzzy logic controller have been proposed to be improving the performance of the Tele-operated robotic surgical systems. The robotic surgical platform for the resection of cancer tissue in the gastrointestinal tract is encouraging.

II. TELE-OPERATED ROBOTIC SURGERY

The robotics systems in the medical field aims to exploits and complement human capabilities since its prospective advantage are to upsurge the operational efficiency, to increase the dexterity and improve the

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observational capabilities of the surgeons. The robotics systems used in surgery can be thought of as smart surgical tools able to improve the efficacy, safety, and reduce in the burgeon of the surgeons while meaning to the patients possible lower morbidity and fast recovery times.

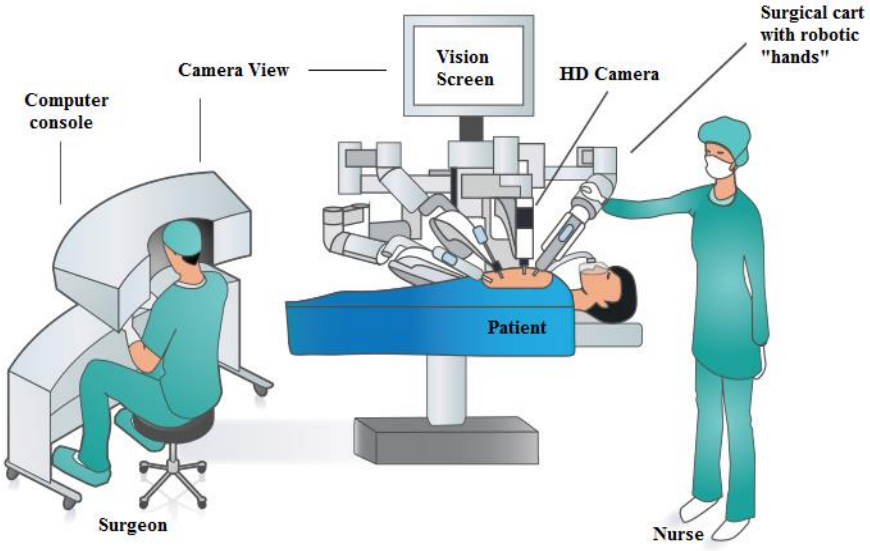

Figure 1: Structure of Robotic Surgery.

We can see the robotics systems used in the resection of cancerous tissue on the gastrointestinal tract as platforms able to outperform conventional methods and improve the diseases free survival of the patient's possible lower morbidity and faster recovery times. The integration of different sensors are increased field of vision along with the effortless sterilization process can be increase the advantages that these types of systems have been compared to the traditional surgery. The robotics platform promises to improve the surgeon's dexterity thus enhancing their technical performance which has been demonstrated to be a key point in reducing the tumours recurrence and alleviate the post site metastases associated with Minimally Invasive Surgery (MIS).

Minimally Invasive Tele-Operated Robotic

Conventional MIS comprises advantages as the already mentioned reduced hospital stay and better cosmic results. In spite of these type of procedures come with drawback compared to open surgery as it is the losses of the stereoscopic depth perception, the not directly control of the visual space by the surgeons. Since the endoscope is controlled by an assistant and the high fatigue of the personnel. The rigid instruments and the fulcrum effect at the port side in the laparoscopic procedure to reduce the dexterity capabilities of the surgeons along with the sensor feedback. In conventional laparoscopy task like suturing and ligation are more complex. The advanced laparoscopic surgery has a technically more demanding learning curve if compared with open surgery being this especially applicable to colorectal surgery as its narrowed operative field. Robotic Technology was introduces to defect some of the constraints.

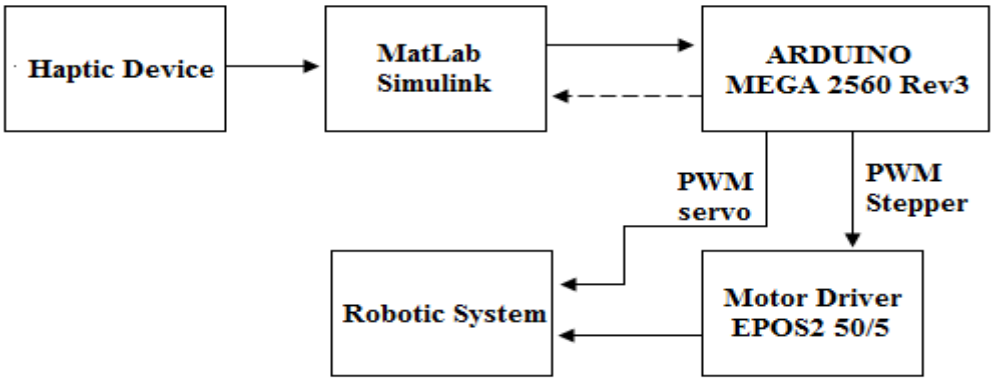

Figure 2: Block Diagram of Tele-Operated Robotic.

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Intuitive Surgical Inc came out with a robot prototype with prospective use in Minimally Invasive surgery (MIS) titled the da vinci, which as master / Slave manipulator with three arms, one for the endoscopic camera and the other two arms aiming to hold the operating instruments. The da vinci surgical system has improved their accuracy and outcomes are vast. The gastrointestinal tract, as its complex S-shaped and anatomical position imposes demanding task to both open procedures and conventional laparoscopy. The surgical system enables a fine dissection in the narrow and deep pelvis, improving accuracy and reduces the complications. These system advantages are intended to achieve better oncology and functional outcomes after rectal cancer surgery.

Tele-Operated Robotic Endoscopy

The endoscopy exploits the nature orifices of the human body as point of access to achieve specific target in the gastrointestinal tract. The robotic endoscopic system have been developed aiming to cover these needs and to improve already implemented and trusted methods as Endoscopic Submucosal Dissection (ESD) or Endoscopic Mucosal Resection (EMR) by enhancing their safety, accuracy, effective and reliability to enhancing the intervention capabilities of endoscopy and by increasing the available tools to expand their aspects of moving motion to improve their surgeons dexterity. The surgical robotic system for endoscopic is a robotic systems designed to be controlled by two haptic devices. It is composed of two robotic arms, each which six degree of freedom. The robotic system was designed to enable an adaptable position of the manipulators by introduce two scrollable parts managed by the DC motors. The scrollable parts of the robot are contained inside the cap body while on exploration inside the intestines and once the target area is reached they are deployed. The system positioning feedback is directly provided by the endoscope.

III. CONTROL METHODOLOGY

To design the Control system in practice requires cyclic effort in which one of the performing again between the design, simulation, testing and implementation. A control system is designed to regulate a system, aiming to achieve the desired output values while ensuring an aspired level of performance. Robotic surgery proposes to using the surgeons capacities and transform them into a developed task delivered in the distance. The design and consideration for reliability, safety and the human robot interface are fundamental importance and a method to command this system is the master / slave arrangement. The master / slave layout consist of several subsystems. One is the master manipulator and is responsible for collecting the information coming from the human operator, allowing commanding the salve arm. Another subsystem is the slave manipulator which is executes the operation using end effectors that mimic motion of the master manipulator. The control subsystem deals with the regulation of the plan to provide exact and fine motion both to the master and slave manipulators. The information is the unit of leading in charge the information path is transmitted while ascertain that all components on the systems of the data are addressing properly.

Proportional Integral Controller

A Proportional Integral controller is a feedback control loop that calculates an error signal by taking the difference between the outputs of a system. The controller offers simple, clear functionality, applicable and more effective solutions. The PI controller maximum minimize the change in error in the input of the system while treatment to both transient and steady state. That error signal e(t) is computed from the processed measured signal y(t) and the desired reference signal r(t). The proportional gain K_p provides an overall control action to the error signal. The integral term K_i reduces the steady state errors.

$$G(s) = K_p + K_i / s \quad (1)$$

The PI controller is a closed loop system is shown in Fig. 1. We have

$$e(t) = r(t) - y(t) \quad (2)$$

$$u(s) = K_p e(t) + K_i \int e(t)\, dt \quad (3)$$

In demand tuning the characterized by having the need to be retuned periodically and whenever changes occur in the dynamic process while the adaptive tuning posses a range of changes that can be limit and covered, the model is need for determine initial PI setting. If once the PI controller is configured properly it can be monitor the process constantly and the parameters are adjusted.

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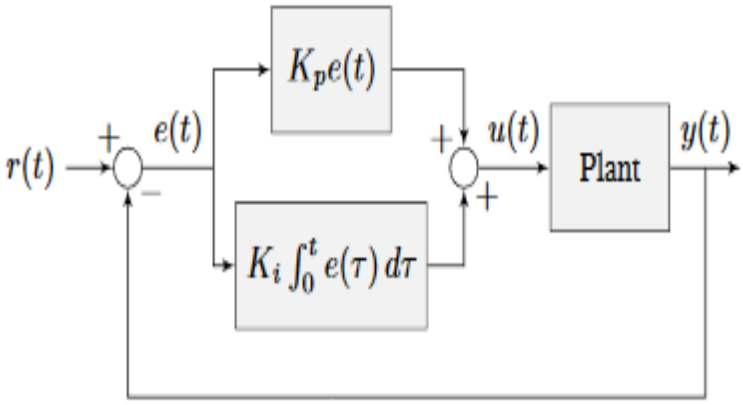

Figure 3: Block Diagram of PI Controller.

To introduced into their PI controller hardware module with adaptive tuning or tuning on demand or both function, aiming at decreasing the limited capacity of PI schemes to regulate accurate non linear systems. The PI controllers are characterized for having fixed gain, as a result they are not entirely accurate when dealing with non linear sysems. The PI controller are designed to reduce the steady state error, the transfer function must be increased. The equation indicates increase in the transfer function. The PI controller are introduce in control systems, the steady state error of the system extermly reduce without effecting the stability of the systems.

Fuzzy Logic Controller

The fuzzy logic controller is a method of rule based decision making used for process control and expert systems. The controller employes the controlling rules of conditional linguistics statement on the relationships of the system variable and follow the behavior of a operator. This controller as shown in Fig. 4 it consist of four main parts they are fuzzification, inference engine, rule based and defuzzification.

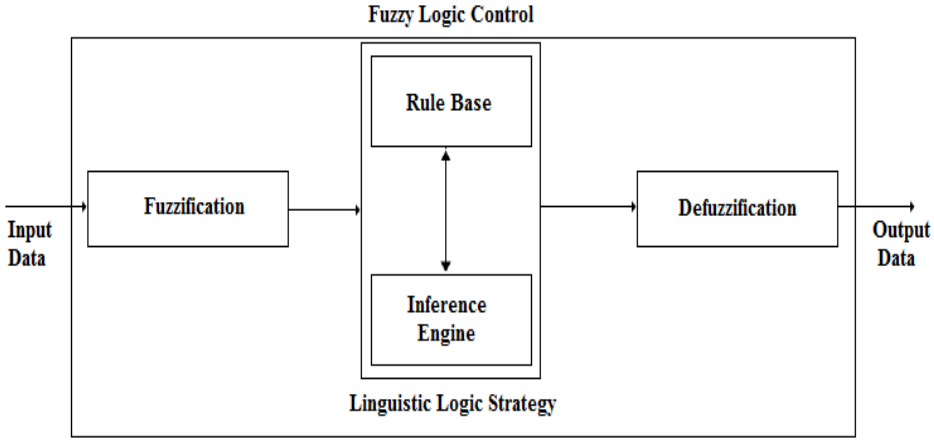

Figure 4: Block Diagram of Fuzzy Logic Controller.

The fuzzy logic controller is deeply relatable to the human its suitably design the membership function and its rules. Fuzzification is the process of input values with the linguistic variable term of the corresponding input linguistic variable performing by the membership function. The fuzzy controller utilized the fuzzy rules to determine the resulting linguistic variable term of the output. The defuzzification is in charge of transforming the membership function of the linguistic variable outputs.

Fuzzy gain scheduling PID Controller

The Proportional Integral Derivative (PID) Controller is used in control systems due to its suitable performance and simple structure, its parameters are initially calculated according to the processing parameter. The combination of the fuzzy-logic and PID controller in which the PID parameters can be adjusted in system by an adaptive based on a fuzzy interface engine to next level in the control system design.

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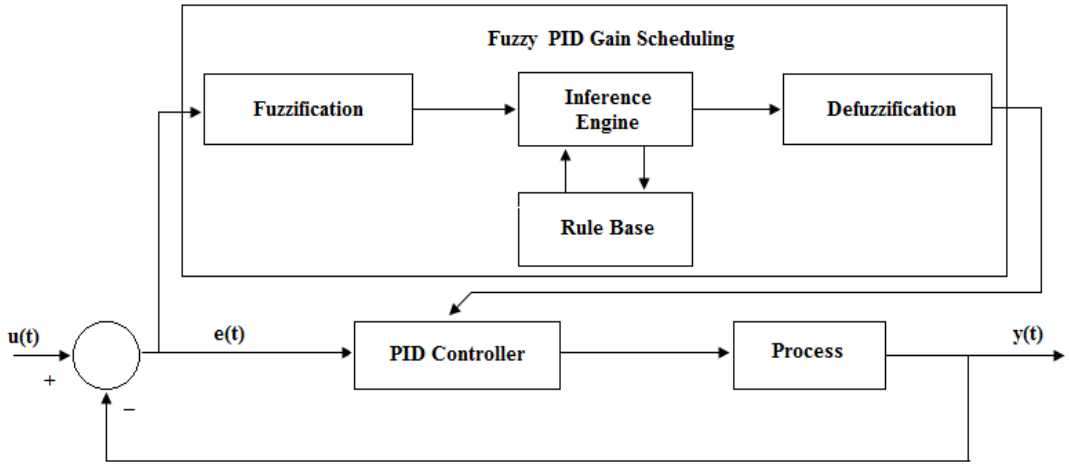

Figure 5: Block Diagram of Fuzzy PID Gain Scheduling.

The input method is required to keep the transform function of this data proportionally and the range will be automatically adjusted within gain to achieve the target of control to be normalized the data. The fuzzy PID controller allows manage the velocity, current and position of DC motor. The driver can be tuning the PI parameter in the system it response the type of DC motor deal with tuning the process of system is optimized. This type of dc motor is highly sensitively to variation of current to model the fuzzy PID controller is ability to control the fluctuate the current depend upon torque and load. Figure 6 as shown the simulation of the controlling system.

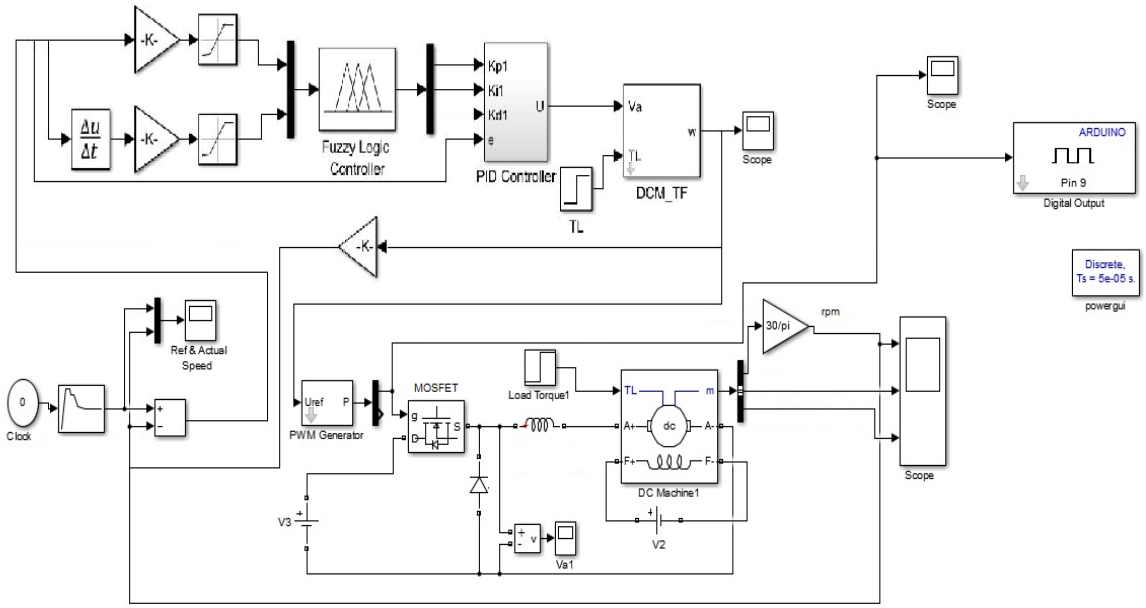

Figure 6: Simulation of fuzzy PID gain scheduling motor control.

The fuzzy PID controller includes in driver is composed of velocity and current loop. The current control the movements can be regulated the force and torque of the DC motor. The fuzzy PID gain scheduling is a method that allow adjust the gain of the PID controller depend upon the error of input. The simulating loads and frequency PID controller approach that not perform as desired non linear systems. This method reduces the error performance of system.

IV. RESULTS AND DISCUSSION

The result obtained from the tuning process of the DC motor is simulation of the fuzzy PID controller to the output collect from the approach of gain scheduling. The error current can be effect the DC motor. The output value of the fuzzy PID gain scheduling is the response of the PID current loop.

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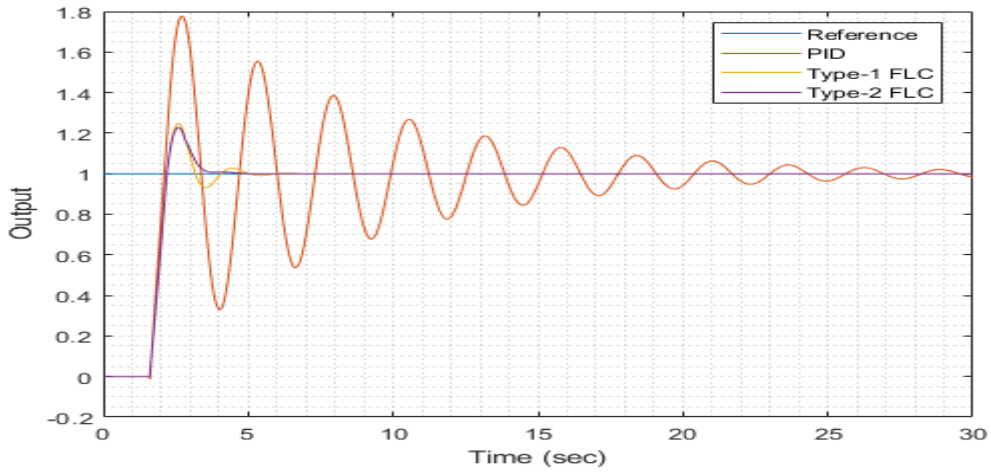

Figure 7: Output waveform of fuzzy PID controller.

The haptic device allows the operator to comfort and realistic environment to perform the surgery. The gain scheduling of fuzzy PID adapted to PI controller these improving their adaptability and non linear.

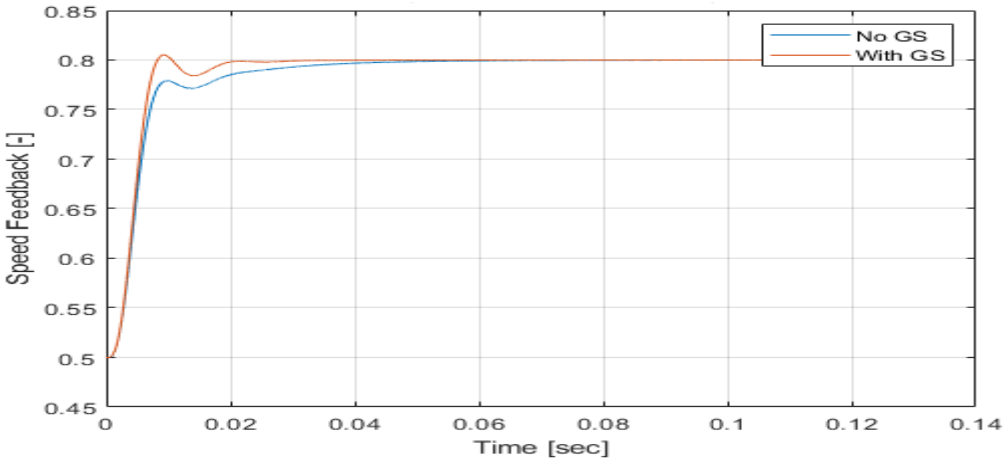

Figure 8: Output waveform of motor control with and without gain scheduling.

The fuzzy PID gain scheduling is improving the control stability and regulates the flow of current in DC motor. The simulation of the fuzzy PID gain scheduling was integrated with velocity of PID controller and its accuracy was compared with the other velocity control without gain scheduling.

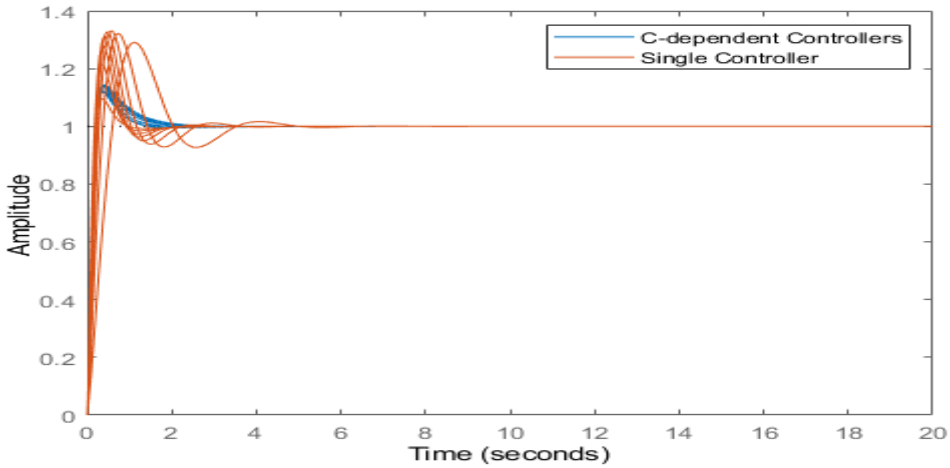

Figure 9: Output waveform of controller.

The haptic device enable the interaction of the robotic surgery system is valuable the surgeon to adapt easier

and learn faster to control the system it's reduce the error. The feedback of the haptic device will be providing the information about the surgical interaction with the tissues the more efficient to the surgeons. The robotic surgery is efficient in accuracy, safety and precision of the patient's data. To improved the surgical system in the gastrointestinal track by using fuzzy logic controller in robotic surgery.

V. CONCLUSION

The robotic surgery platform is highly valuable as its surgeon operates to familiar and easy to control the surgical system. In robotic platform along with risk of metastases has paved the way towards the developed new robotics surgical tools for the method of endoscopic. To haptic devices are enabled in the surgical arms, to control the arms in the robotics the control system are implemented to control the surgical system. The DC motors are kept in outside of the robotics and that are connected with cable systems, where each of the DC motors are manage with the tools. The PI controller is used to control the overall function of the robotics. The fuzzy gain scheduling PID controller is used to control the DC motor of the surgical robotic systems. In this control the system reduce the error and more accurate in the surgical system, the haptic device feedback to provide information regarding the system due to interaction with the tissues to improve the efficient and it more appealing to the health care specialist.

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