Issues and Application on Robot Control Using Internet

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Abstract:

Robot control using internet basically uses the internet as command transmission medium and obtain feedback signals. This paper introduces the fundamentals of such robot control relationships. Four variations of robot control relationship have been identified and they are one to one, one to many, many to one and many to many. Samples for each of the relationship are given. The development of internet are further considered in the various applications areas. The applications made by various projects are referred. Some research issues and problems brought up by the projects are also reflected. The issues directed are time delay, communication, dynamic environment and dispersing the whole robot system on the internet.

Keywords: Internet robot, robot control

1 Introduction

Robot control using internet basically uses the internet as command transmission medium and obtain feedback signals. Our laboratory is developing a technique to remote control a group of autonomous mobile robots (Tarou) by mobile phone or via the internet [1]. The remote control equipment used in Tarou is transmitter/receiver RDIS/LT-08 which has 8 input ports, 8 output ports, 2 analog input ports and RS232 port.

2 Robot Control Architecture

Internet operated robot generally uses hardware which includes the robot, the robot server workstation, web server workstation and other user computers [2]. The user access the worldwide web and give commands. The web server receives these commands and transmits them to the robot server. The robot server decides the robot motion and behavior. The tasks are transmitted to the robot which is supposed to carry out the commands. The relationship of the user and the control system can be classified into four control architectures which are; one to one, one to many, many to one and many to many.

2.1 One to one

An interesting internet controlled pet robot with arithmetical inclination has been developed within this architecture [3]. The robot is programmed to recognize the image signals of the arithmetic operation using the binary method. If the equation is right it will nod and if the equation is wrong it will shake its head

2.2 One to many

The ARMAGRA Project [4] also depicts the same robot control architecture. It involves a few robots with an assistance system for disable persons. Both robot projects illustrated uses a decentralize system which enables each part of hardware to be develop individually. The flexibility of decentralize system is also economical as the web server workstation can be shared through LAN or a WAN. Our robot TAROU allows one remote user to control a group of autonomous robots. The operator sends commands using interface in HTML to the internet host onto the internet system. The command is received by RDIS/LT which is attached to Tarous body. Upon execution of command, reports are generated by Tarous and sent to the operator.

2.3 Many to one

A system that allows multiple users to control and industrial arm robot has been developed [2]. Each users monitors different sensors and submits control inputs based on different control information. The inputs are combined to a single control signal for the robot. However, time delay and transmission latency remain as two prominent areas of concerns.

2.4 Many to many

Marin *et all* [5] has described an experiment on multirobot internet based architecture. In the experiment, they tested on several telerobotic configurations that enable access from multi-users. They highlighted that having many robots connected to the servers manager would cause a bottleneck and proposed a configuration for the synchronization of the robots operation and

specification for reliable multirobot tasks.

3 Application

The literature reviews have revealed many aspect of internet robot. Many of it has focused on the technical aspect of the robot system development. This part of the paper discusses the research of internet robot which has been developed within an application area. The recent developments in the research and development for internet based robot have been focused on eight areas of application. The areas identified are; industrial robot, medical robot, entertainment robot, autonomous robot, service robot, hazardous environment robot, educational robot and other types of robot.

3.1 Industrial Robot

Industrial robots are used in various areas in manufacturing and production environment. The robot are used to assemble parts, paint, weld and do other tasks. An internet based robotic assembly planning system namely the WebROBOT has been developed using a modular architecture [6]. User can model desired assembly sequence using a variety of parts in the assembly area. The objects are classified onto two categories which are the stationary objects and the movable objects. Users plan an assembly sequence using the movable objects onto the stationary objects. A common assembly done by the robot involves placing five cylindrical parts into an array of holes of a block in polar fashion. This way the user can specify the assembly operation while the robot converts the orders into detailed robot path by computing robot joint positions using inverse kinematics. The ability to automatically generate the robot path enable the WebROBOT to carry out robot programming at the task level compared to the commonly used strategies which is at joint level or teach-in type robot programming.

An added feature of industrial robot has been developed using the Virtual Reality Modeling Language VRML model [7]. The VRML model is developed using various software components and it has the capability to control and monitor the robot via the internet. The system is designed as such it allows users to control the robot without the need to know the details of the programming language used. In factory environment, it allows the operators or managers to visualize the robot system in the factory online at remote locations.

3.2 Medical Robot

The main advantage of medical robots in ultrasound examinations is it alleviates the problems of human physical conditions among the sonographers [8]. This robot assisted system for medical diagnostic ultrasound helps to reduce the problem of having to perform awkward body positions in doing the test. The system comprises of a master hand controller, a slave manipulator and a computer control system. It enables the operator to remotely position the ultrasound transducer onto the targeted patients body parts. The teleoperated quality enable the operator to position the ultrasound at ease with additional assistance of machinery force and image controllers enable the robot to be remotely position and used in telemedicine.

Another medical robot system is developed by the Kanagawa Institute of Technology in the area of Face Robot [9]. The robot system is within a personal computer (PC). The purpose of the robot is to remind the patients when and which medication is to be taken using facial expression, a voice communication system and a display on the PC.

3.3 Entertainment Robot

Entertainment robots are developed as a variation of amusement means. However its potentials can be extended for other arising needs. The interesting internet controlled pet robot with arithmetical inclination has been explained earlier is a good extension of entertainment robot. Apart from the basic movements of walking, seating and standing up it can also do fundamental mathematics calculations. The pet robot can determine the equation of addition, subtraction; multiplication and division are correct or otherwise. If the equation right the pet robot will nod and if it is wrong, the pet robot will shake its head. Another entertainment robot is being developed by the LunaCorp Inc. and Carnegie Mellon University [10]. They aimed to operate a pair of teleoperated robotic vehicles on the surface of the moon with a television network as customer.

3.4 Service Robot

The service robot can provide many services in home or office. Sawasaki *et all* [11] describe the application of Humaniod robots to building and home management service. The system enables users to remote control humanoid robot in home environment. Another service robot WorkPartner has been developed to perform tasks like garden work, transferring of light weight obstacles and environment mapping. The centaur like service robot is a hybrid, lightweight outdoor robot [12]. Its hybrid system combines both legged and wheeled locomotion,

providing good terrain negotiation and large velocity range.

3.5 Autonomous Robot

Unlike the conventional conveyance robot system which uses the line trace system, the autonomous robot can make judgment and equipped with dynamic sensors. Ohchi *et all* [13] described its robot which can follow the infrared rays emitted by a transmitter on a guide and move to the destination. An interesting autonomous robot with book browsing system has been developed [14]. The development has been made with consideration on the application and usability in book browsing environment. The aspects of movement towards the bookshelf, extraction and return of book and book perusal have been developed.

3.6 Hazardous Environment Robot

Environment such as managing spent nuclear fuels is obviously hazardous due to its high radioactivity nature. Cragg and Hu [15] proposed an integrated architecture which combines the strengths of available distributed computing, autonomous multiple robot and internet robot architectures for the use in nuclear decommissioning environment. Korea Atomic Energy Research Institute (KAERI) has developed a 3D graphic simulator to monitor the operation of multiple devices operated in such hostile environment [16]. Most of the devices are operated within a hot cell involving various sensors. They have successfully transmit the operational information from the actual system to the graphic workstation in realtime and visualization of the operating devices was simulated successfully in the virtual workcell.

3.7 Educational Robot

Safaric [17] has made an application of internet robot for education and training in using expensive equipment. The trainees uses offline virtual environment for task planning which then, exported to remote physical hardware through the internet for robot execution. This method has increases the training possibility and it is low cost. The downtime of the critical equipment is minimized while the gaining of valuable experience is minimized.

3.8 Other Internet Based Robotic

A space robot experiment ROTEX has been carried out [18]. One of its control modes operated from the ground using predictive computer graphics.

4 Research Issues

Most recent researches highlighted the issues concerning the robot work environment, communication delay and the tools needed for robot performance.

4.1 Usage in Dynamic Environment

Using such robot in dynamic environment is a concern due to a few reasons. One of the concern is on the information gap about the robot remote workplace. Virtual Reality (VR) is one of the common counter measure [16]. 3D graphic simulator is usually used as the human interface for robot in remote place operation. It is also used to visualize the work place environment in offline simulation to preview the robot movements in virtual workcell before operating the real robot. The KAERI project uses real time monitoring by gathering the task based operation data from the sensor to the graphic workstation which is then used to simulate the operation of the real device [16]. They proposed dedicated communication protocols and dividing the simulation programs into a number of small modules to execute each event massage from the control computer.

4.2 Communication, Time Delay and Other Unresolved Issues

The underlying problems of communication and time delay are rooted in the data transmission of the robot and the operator. The whole system also can be upset due to irregular time delay. Accumulation of these problems then leads to time varying system which requires various control methods. Kikuchi *et all* [19] proposed a system which consist of three subsystems; a bilateral teleoperation subsystem, a visual information subsystem and an environment predictive display subsystem. The first subsystem is stabilized using the virtual time delay method and the second subsystem transfers the visual information. Finally the third subsystem predicts the behavior of the environment for the operator. Other theories proposed on maintaining the system stability and synchronization of operator and robot terminal. This would involve predictive methodology including traditional predictive control, internal model control and Kalman filtering [20]. Other issues involve having the whole robot system being disperse on the internet. The sensor, the operator and controller are located in different nodes and coordinated via internet connection [21]. A perfect example would be a homeland security robot which have sensors at various locations, operator and the robot at remote places, all connected through the internet for full execution.

Conclusion

The direction of research for robot control using internet is patterned on having the operator and the robot in remote areas. The capitalization on true quality of the internet should be reap for closer correlation.

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