BILATERAL CONTROL WITH VIRTUAL MODELS

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ABSTRACT

Researches on Teleoperated robots have been carried out for a long time and it has been developed in several aspects by now. Bilateral control is one of the areas which is researched under teleoperated robots. This paper consist of discussion on how bilateral control is used in teleoperated robots and a derivation a virtual model for a simple bilateral control system with two1DOF manipulators connected by a torsion spring.

Key words**:** Bilateral Control,Haptics, Teleoperation, Force feedback

1. INTRODUCTION

Tele-operation or Tele-manipulation is one of the most researched areas in the field of robotics. Teleoperated robotic systems have been used in many real world applications such as explosive disposal, hazardous material handling. On the other hand autonomous robots have been successfully implemented in applications such as automotive manufacturing offering high productivity reduced cost and higher quality. A teleoperated system or a human involved system offers more feasible solution when considering more dynamic real world tasks in unpredictable environments. The Human interaction overcome the intelligence limitations of the robotic system by introducing desired capabilities to the robotic system, such attributes are adaptability to a variety of environments, high level of intelligence. In tele-manipulation human operator has to perform a given task on a remote environment. To capture the commands given by the operator a local robotic interface is used, called the master. When operator commands the local robot, it captures the commands and transmits them to the remote robotic interface through a communication medium. This remote robotic interface is known as the slave. Slave's task is to replicate the movements of the master. The operator's experience close to real if there is a method to operator to know about the interactions of the slave with the environment. Feedback information from the slave can be obtained in several ways such as visual displays. The ideal method to improve the operator's ability is to feedback the forces acting between the environment and the slave [5]. "When the force at the slave side is reflected back to the human operator it is said that tele-manipulation is controlled bilaterally" [1]. Block diagram of a bilateral control system is shown figure 1 [2].

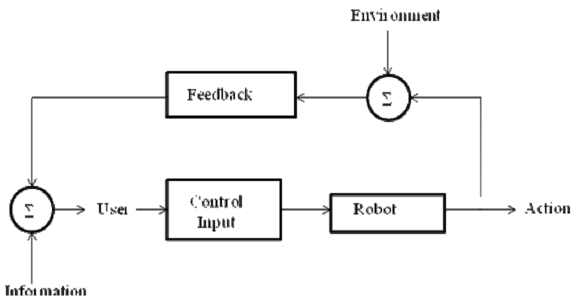

Fig 1 : Bilateral Control Block Diagram

2. METHODOLOGY

The system have to be modeled is a vertically mounted two similar 1DOF manipulators connected by a torsion spring (Figure 3.1).

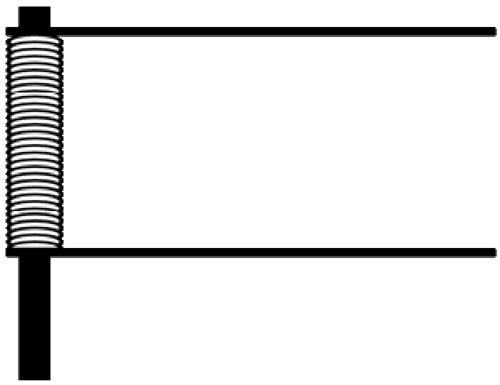

Fig 2: Equivalent Mechanical Sytem

It was assumed that frictional are not present in the system and the system is always at rest before it moves. When developing a mathematical model for virtual model we have to consider in which manner a movement of manipulator1 is replicated at manipulator2 and on the other hand we have to consider the feedback force exerted on the manipulator 1 due to the inertia of the manipulator 2. Consider manipulator 1 is moved by an angle of θ1 and let's take the rod2 is rotated by an angle of θ1 in response to master's movement

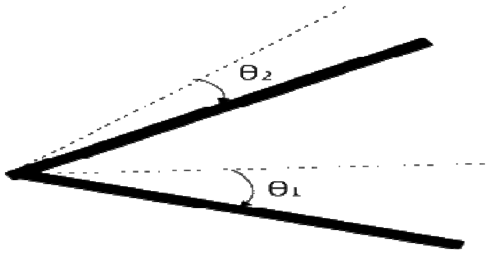

Fig 3:Master and Slave Movements

Applying $\tau = I\ddot{\theta}$ for manipulator 1 and 2

where τ - Torque, I – Inertia, θ - angle ;

$$I_1\ddot{\theta}_1 = \tau - k(\theta_1 - \theta_2) \quad (1)$$

$$I_2\ddot{\theta}_2 = k(\theta_1 - \theta_2) \quad (2)$$

Taking the laplacian of (1) and (2) we get,

$$I_1[S^2\theta_1(s) - S\theta_1(0) - \ddot{\theta}_1(0)] + k\theta_1(S) - k\theta_2(S) = \tau(S) \quad (3)$$

$$I_2[S^2\theta_2(s) - S\theta_2(0) - \ddot{\theta}_2(0)] - k\theta_1(S) + k\theta_2(S) = 0 \quad (4)$$

Since a system which is initially at rest,

$$\ddot{\theta}_1(0), \ddot{\theta}_2(0) = 0$$

Since two manipulators are equal.

$$I_1 = I_2$$

By (3) and (4) transfer function of the master's force to slave's position can be derived,

$$\frac{\tau(S)}{\theta_2(S)} = \frac{I_1^2S^4 - 2KI_1S^2}{K} \quad (5)$$

And also the transfer function for the reaction force exerted by the slave on the master is given by

$$\frac{\tau'(S)}{\theta_2(S)} = I_1S^2 \quad (5)$$

Implementing these functions virtually, a similar operation kind of operation as the mechanical system can be achieved when the spring is not present in the system. The next step of modeling system is to simulate the system in a computer environment with the help of the derived mathematical model. There, it can be observed the behavior of the slave according to the various force applied to the master and forces exerted on master by the slave.

3. CONCLUSION

When implementing the above system physically using the virtual model, we can't expect the exactly the same behavior as the mechanical system. This happens due to delays of actuators and sensors and also the data processing and communication delays. At slower speeds nearly similar behavior to the mechanical system could be observed. But at higher speeds, faster data acquisition and processing methods actuators and sensors with low response time should be used in order to obtain that behavior. Communication delay is the one of the significant issue in tele-operated bilateral control systems. When the master and slave are located far away from each other delays can arise when transmitting data through communication medium. As an example when the tele-operation uses the a packet switching network such as internet as the communication medium there can be considerable amount of delay when transferring data from master to slave and slave to master. When this delay can't be neglected the stability of the system can't be guaranteed. [4]

4. REFERENCES

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