Human Enhancement via the Transfer of Power and Information Signals

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Abstract

A human's ability to perform physical tasks is limited by physical strength, not by intelligence. We define "extenders" as a class of robot manipulators worn by humans to augment human mechanical strength, while the wearer's intellect remains the central control system for manipulating the extender. Some major areas of application for the extender include manufacturing, construction, loading and unloading aircraft, maneuvering cargo in shipyards, foundries, mining, or any situation which requires precise and complex movement of heavy objects. Our research objective is to determine the ground rules for the control and design of robotic systems worn by humans through the design, construction, and control of a prototype experimental hydraulic extender for manufacturing operation.

Definition

Figure 1 shows one of the experimental extenders at the University of California, Berkeley. The goal of this research is to determine the ground rules for a control system which lets us arbitrarily specify a relationship between the human force and the load force. In a simple case, the force the human feels is equal to a scaled-down version of the load force: for example, for every 100 pounds of load, the human feels 5 pounds while the extender supports 95 pounds. In another example, if the object being manipulated is a pneumatic jackhammer, we may want to both filter and decrease the jackhammer forces: then, the human feels only the low-frequency, scaled-down components of the forces that the extender experiences. Note that force reflection occurs naturally in the extender, so the human arm feels a scaled-down version of the actual forces on the extender without a separate set of actuators.

Three elements contribute to the dynamics and control of this material handling system: the human operator, an extender to lift the load, and the load being maneuvered. The extender is in physical contact with both the human and the load, but the load and the human have no physical contact with each other. Figure 2 symbolically depicts the communication patterns between the human, extender, and load. Forces between the human and the extender and forces between the load and the extender are measured and processed to maneuver the extender properly. These measured signals create two paths of information transfer to the extender: one from the human and one from the load. No other external information signals from other sources (such as joysticks, push buttons or keyboards) are used to drive the extender.

Our research focuses on the dynamics and control of machines involving the transfer of both information signals and power. The information signals sent to the extender computer must be compatible with the power transfer to the extender hardware. Our research work presents this compatibility in terms of closed-loop stability [1, 2, 3].

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References

1. H. Kazerooni, "Human-Robot Interaction via the Transfer of Power and Information Signals," IEEE Trans. on Systems and Cybernetics, Vol. 20, No. 2, March 1990.
2. H. Kazerooni, S. L. Mahoney, "Dynamics and Control of Robotic Systems Worn By Humans", ASME Journal of Dynamic Systems, Measurement, and Control, Vol. 113, No. 3, pp.379-387, September 1991.
3. H. Kazerooni, J. Guo, "Human Extender", ASME Journal of Dynamic Systems, Measurement, and Control, Vol. 115, No 2(B) June 1993.

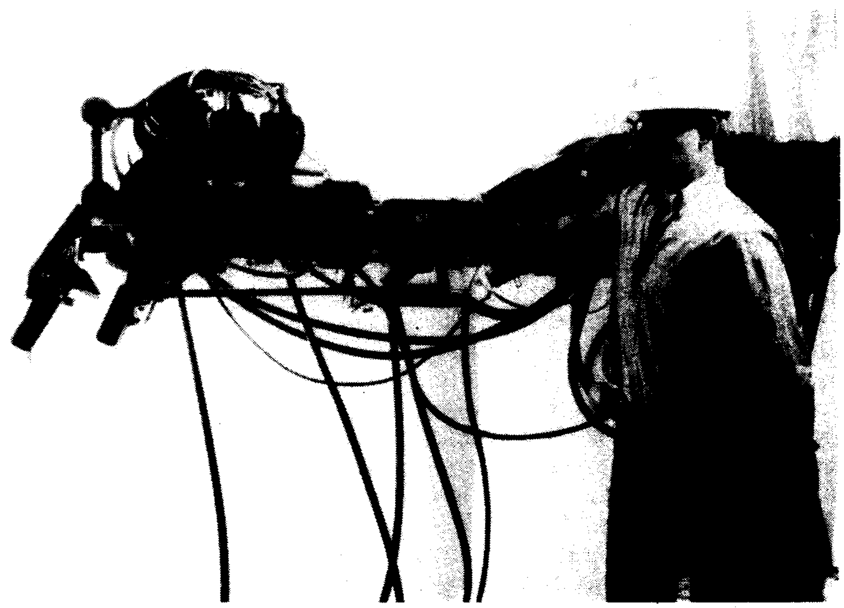

Figure 1: A six-degree-freedom extender for right-handed operation for foundries.

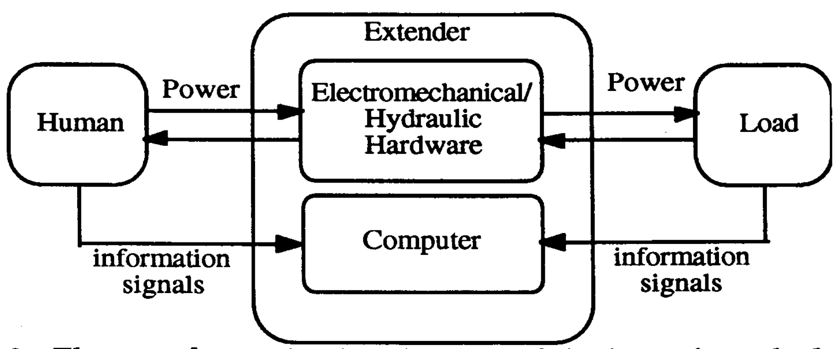

Figure 2: The extender motion is a function of the forces from the load and the human, in addition to the command signal from the computer.