Design of a Robotic System Which Interacts with Human Subject

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ABSTRACT

Designing of a robotic system which interacts with human subject to examine the motor control behavior of the human subjects. A slider-crank mechanism was designed as a manipulandum. This mechanism converts rotary motion to straight-line motion on a rail. The dimensions of the slider-crank mechanism are optimized. The task of the experiment keeping the pendulum on a cart upwards by giving the force inputs to the cart. The Inverted pendulum on a cart is virtual and works on Simulink. Thanks to virtual reality a wide variety of experiments can be done according to needs in the future.

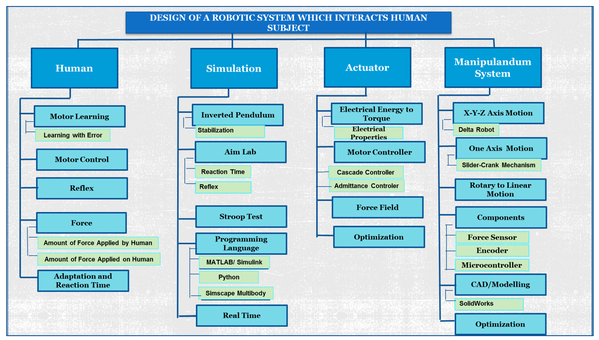


Figure 1: Problem Tree

OBJECTIVE

- Design virtual inverted pendulum which is controlled by slider-crank mechanism.
- To implements a motor that is connected to the slider-crank mechanism to interact with the human arm.
- Different tasks such as inverting the control of the mechanism or adjusting the force which is applied to the human arm are planned.
- Design an admittance control system to control setup.
- Create different task simulations for different applications.

METHODOLOGY

The problem which is "Design of a Robotic System Which Interacts with Human Subjects" is a part of a wide topic. Manipulandum and different kinds of robots are examined to improve the knowledge and discover new approaches. The acceptable safety conditions are analyzed in the project. After an extensive literature search, forward and inverse kinematics were calculated. By setting boundaries a model was created as a result of calculations and optimization and a solid model of this model was drawn. Then Simulink Simcape Multibody was used to import this solid model into the Simulink environment. A cascade controller has been added to suit the system. Since the human factor is involved, an admittance controller, which is widely used in such applications, was designed and integrated into the system. Thus, a system that works in real-time and interacts with a human has emerged.

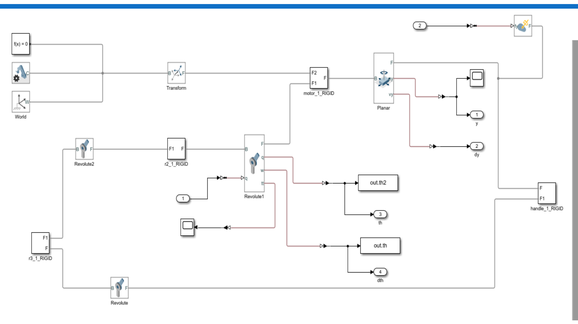


Figure 2:Simulink Block Diagram of the Mechanism

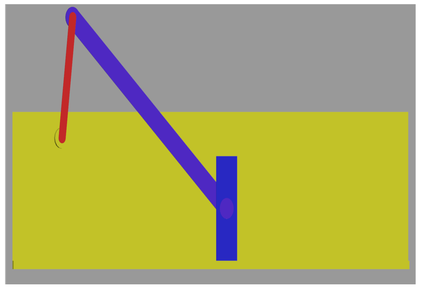


Figure 3:Simscape Multibody Simulation

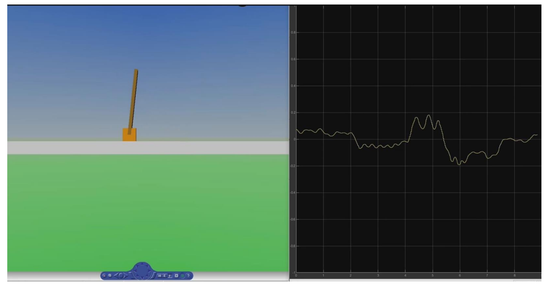


Figure 4: Virtual Inverted Pendulum from Simulink Real Time

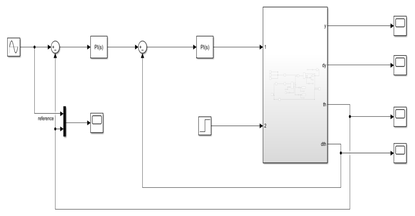


Figure 5: Cascade Controller

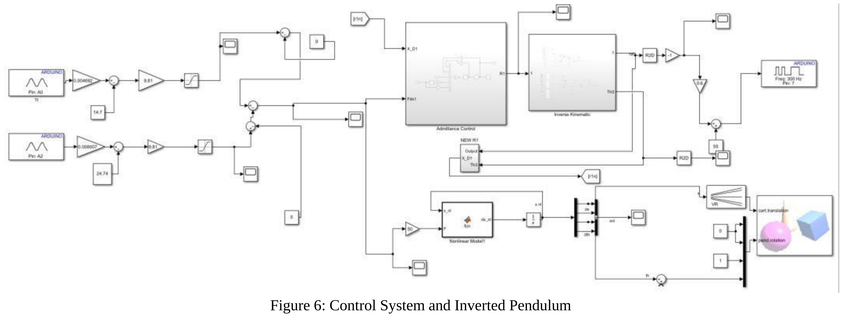
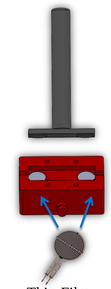


Figure 6: Control System and Inverted Pendulum

FINAL DESIGN AND MANUFACTURING

The design starts from the links which are chosen as aluminum and the link lengths are supposed to be from centerline of a joint to the centerline of the next joint. Aluminum profile lengths and joints lengths are arranged according to the link lengths calculated. Joints are produced from PLA material by a 3D printer. Used the 19x10x5 bearing at the joints to make the system move. Miniature linear guide and rail used for decrease friction of system. Two thin-film pressure sensors measure the linear force of the subject. So servo motor can respond according to experiment. As microcoltroller Arduino Due is chosen because it is easily accessible, has a lot of resources and meets the needs with its 32-bit processor.



Thin-Film Pressure Sensors Application on the Handle

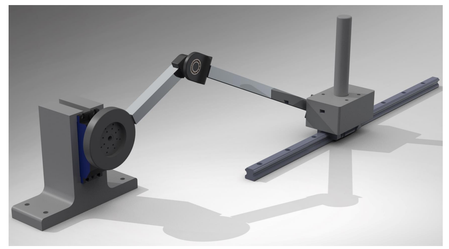


Figure 7:CAD of System

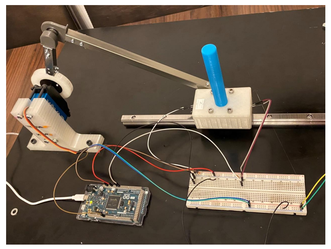


Figure 8:Protoype of System

CONCLUSION

The project "Virtual Inverted Pendulum on a Cart Controlled by a Slider-Crank Mechanism" is for improving and testing motor control and learning. This project is also for obtaining data about motor learning and control. Since this project has two separate parts (pendulum and mechanism), the work has been done on two separate side. One of them is virtual and the other one is a real working prototype mechanism. The research shows that motor learning can be simulated and improved by patterned human-robot interactions.

REFERENCES

For References and More Information Please Scan the QR Code