

Observer Based Robot Arm Control System

Functional Requirements List and Performance Specifications

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October 30, 2011

Introduction

Control systems exist in many applications today, from home thermostats and vehicle cruise controls to engine temperature regulation and missile-guidance systems. Many control system designs exist, and one of the newer, more sophisticated concepts in modern control systems is the concept of observers.

Observers are algorithms used to predict a system's response. The chief benefit to using observer control systems is cost. An observer can predict a system's response without using numerous sensors which can greatly reduce the cost of a system. The observer uses data collected from sensors to predict information that either cannot be measured or is too costly to measure. Also, because the data is derived from the observer and not read from a sensor, the factor of noise is eliminated. With this control method, we can control parameters that cannot be easily measured such as motor current or fluid flow rate. This project focuses on using observers to control the position of two robot arms which will pass an object back and forth.

Goals

- Learn the Quanser software package and real time control via Simulink.
- Obtain a mathematical model for the pendulum arm and the horizontal arm.
- Design controllers for each system using classical control methods
- Design a controller for each that uses observers to predict the plant's response.
- Evaluate the performance of the two control methods and compare the result.

Functional Description

The workstation for each robot arm consists of the following components:

- PC with Matlab and Simulink
- Motor with Quanser Control System
- Linear Power Amplifier
- Robot arm with Gripper
- SRV-02 Rotary Servo Plant
 - One robot arm will also contain a SRV-02 Rotary Flexible Joint to add another degree of freedom.
 - The inverted robot arm contains a rotary encoder, and the level robot arm contains a potentiometer to measure position.

One robot arm will be configured vertically in a pendulum-like fashion to incorporate the effects of gravity on the arm. The other robot arm will be placed horizontally and will have a flexible joint to add a second degree of freedom that is independent from the base of the system. A closed-loop PID control system will be implemented in Simulink and will use Quanser software to allow real-time control of the robot arms through Simulink.

System Inputs:

- Internal Commands (position)
- Potentiometer Position Feedback (2 DOF arm configuration)
- Rotary Encoder (inverted arm configuration)

System Outputs:

- Position

Block Diagram

The High level block diagram for the project is shown in Figure 3. The command signal is set in Simulink which then sends a signal to the implemented arm controller, which then sends the signal to the arm. Sensors connected to the arm then send feedback to the controller allowing closed loop control. The Power electronics involved with the robot arm controller, the robot arm itself and the sensors all introduce external disturbances including voltage source noise, changes in load, friction, and quantization error.

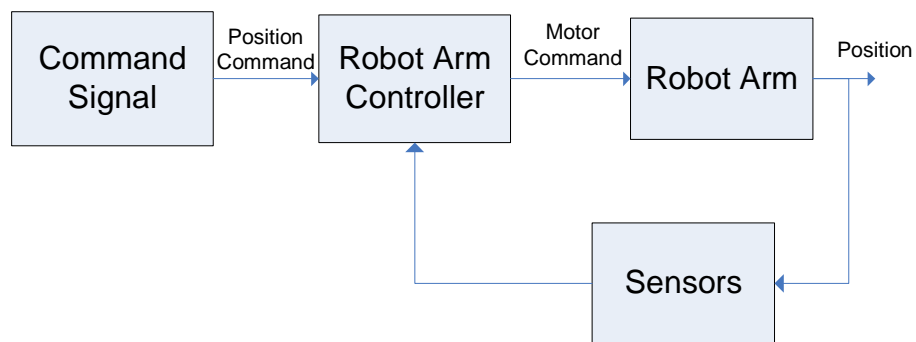


Figure 3. High-Level Block Diagram

The command signal to the system will be a value that we assign in Simulink. This value will be limited to plus or minus 90deg. The position command will be passed to the controller via Simulink. The controller will generate a digital control signal which will be converted to a plus or minus 5 volt analog signal via a D/A converter. The position of the arm will be measure two different ways in the two platforms. The 2-DOF platform will use a potentiometer to measure position. The analog position signal will be fed into an A/D converter. The digital signal will then be compared to the reference signal to generate an error signal. The pendulum arm platform will use a rotary encoder to measure position which is fed into the quad encoder interface to the computer. The signal is then compared with the reference signal to generate an error signal to drive the controller.

Performance Specifications

The level 2-DOF configuration will be controlled using different types of classical controllers and observer-based controllers. The system shall also perform disturbance rejection for a load. The specifications for the performance of this system for a step command of 90deg are....

- The overshoot of the arm shall be less than or equal to **15%**
- The settling time of the arm shall be less than or equal to **2s**
- The phase margin shall be at least **50 deg**
- The gain margin shall be at least **3.5**
- The sample time shall be **10ms**
- The steady state error of the system shall be less than 1 degree.

The pendulum arm configuration will go through the same design process as above. The system shall perform disturbance rejection for a load. The specifications for this configuration given a 90 deg step command are

- The overshoot of the arm shall be less than or equal to **15%**
- The settling time of the arm shall be less than or equal to **2s**
- The phase margin shall be at least **50 deg**
- The gain margin shall be at least **3.5**
- The sample time shall be **10ms**
- The steady state error of the system shall be less than 1 degree.

For both of these systems, the specifications shall hold for loaded conditions. The controllers will be designed to work with the existing system components in the two platforms because the specifications for A/D and D/A converters are fixed.

References

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- [3] George Ellis. "Observers in Control Systems", Academic Press, 2002