Robotic Limb Calibration: Accelerometer Based Discovery of Kinematic Constants

Jeffrey R Croxell[1], Jerry B Weinberg[3], Ryan W Krauss[2], Scott R Smith[1]

Southern Illinois University Edwardsville
[1]Departmen of Electrical and Computer Engineering
[2]Department of Mechanical Engineering
[3]Department of Computer Science

Abstract

Robot arms carry a unique set of challenges with setup for use with inverse kinematics. An automated calibration for such robots would prove beneficial. A solution is discussed utilizing accelerometer feedback on the tip of a robot arm and an automated calibration routine.

Introduction

Robotic arms have established their place as a useful tool in modern society. This includes industrial applications, space exploration and as research tools. Bipedal and humanoid robots are also gaining popularity as toys and as educational and research tools (Weinberg, et al. 2008). Limbed robots of any form carry some inherent difficulties not found in other platforms, such as wheeled or tracked robots. One specific area of difficulty is with setup. Robots with linkages typically require the use of careful measurements and complex kinematic equations for setup and calibration. Not only are these difficult, but if a robot is slightly different or changes, measurements and equations must be reworked. For many people, these setup requirements are not understood without college engineering courses, leaving this type of platform inaccessible to much of the population.

Running a simple startup calibration routine on the limbed robot to solve the complicated kinematic equations automatically would be ideal to make the platform more accessible. Expanding this further, such kinematic self-discovery could be combined with learning algorithms allowing bipedal robots to discover their limbs and take steps on their own much like how children learn to walk.

Inspiration

The typical way to interact with robotic arms is with inverse kinematics. This allows the user to specify a location in three dimensional space where they require the tip of the arm to be located. This makes the arm easy to use at a high level, otherwise users would find themselves controlling individual joints of the arm, and as the complexity of the arm increases, so does this task. It is nice to have this high level control, unfortunately it is also difficult to setup. The more joints and links involved the more complicated the analysis and equations of the arm becomes.

It is the analysis process that makes using these arms difficult for some, but impossible for others. For example, at SIUE this material is taught in a robotics control class that is made available to seniors and graduate students. This makes the platform largely unavailable to students who have not reached this point in their academic career. The other problem comes into play with difficulty and setup time. Even those that know how to analyze these arms may find the process tedious and difficult. This is exacerbated by changes that can occur with these types of arms (part replacements, joint changes, limb changes, etc.) - that can require anywhere from small tweaks to complete reanalysis of the kinematic equations.

On walking style robots the problem is multiplied by the number of limbs you are dealing with on that robot. The unfortunate side effect is that there is an entire platform that is unreachable to a large portion of enthusiasts, educators, and students. If we can make the setup of these platforms completely painless, it would provide an additional platform for many people, and also improve the experience of others that use these kinematic equations on robots.

Chandrasekar and Bernstein (2008) used acceleration feedback in simulation to control a robotic arm. However, we were unable to find any related work on using accelerometer feedback for automated discovery of kinematics for robot limbs.

Method

To make setting up robotic arms easier, the obvious solution is to solve the kinematic equations automatically. These equations are made up of some basic physical attributes of the arm, specifically length of links, joint offsets, joint orientations and joint angles. For the typical arm, limb length, joint offsets and orientation all stay the same while some type of motor drives the revolute joints to various angles. This means that to solve the equations automatically we still need to find a set of known quantities.