STUDY OF JOINT DYNAMIC MODELS USED IN COMPUTED–TORQUE CONTROL OF MANIPULATORS

S. S. TSALIDIS and N. A. ASPRAGATHOS
Mechanical Engineering Department, University of Patras, 26000, Patras, Greece.

Abstract.

In modern robotics technology, high accuracy is desired for the motion of the end effector of a manipulator arm under its control unit commands. Unfortunately, this accuracy cannot be completely achieved, since,among other reasons, there are disturbances introduced by the unmodelled dynamics phenomena of the arm joints. Developing a correct dynamic model (in the form of a set of coupled differntial equations) taking into account these phenomena, for a multidegree-of-freedom manipulator is a difficult task. Recent work has made developing the structure of these equations more or less straightforward for the cases where the links are modeled as rigid bodies. However, a problem that remains is that of unknown parameters that appear in a model, and also of effects such as friction, and flexibilities, which are left out of the model formulation.

Incorrectness or uncertainty in a dynamic model can be split into two portions. Structured uncertainty is what we call the case of correct structural model with all uncertainty due to incorrect parameter values. That is, there exists a correct (but unknown) set of values for the parameters such that the model will match the actual system. Unstructured uncertainty is the name given to unmodelled effects, some of which may be state-dependent and some of which are external disturbances. Unstructured uncertainty arises from sources not considered by the designer, or those that are too complex to model.

Recently, much published work has been concerned with topics such as flexibility of motor shafts and arm links, damping in arm joints and the electromechanical characteristics of the motors. The simplest model proposed is based upon the assumption of

absolutely rigid shafts and arm links. Later publications deal with models that give an insight to several factors that cause uncertainties and errors in the programmed behavior of the manipulators. Several works have been published, where links are considered to be flexible and analogous models are proposed which take into account this physical behavior during motion control. In all these cases many solution of the control problem have been proposed which allow a good control also when a very little ammount of elasticity is present at joints and/or in the links.

In the present work, we will describe a generalized model of a robot arm joint, and will study the behavior in control, at the case where we take into account the unstructured uncertainties, and at the case where the modeling error is largely due to stuctured uncertainty.

We consider a manipulator arm consisting of n rotational joints with corresponding links. Each joint consists of a motor unit and the gear reducer unit. Furthermore, it is assumed that each link of the arm is rigid. In each arm joint, each shaft following a moment of inertia has analogous stiffness and damping constants. Each gear pair transmits a torque. In the present case it is assumed that this power transmission is strongly affected by backlash, a non linear phenomenon arising at each gear pair. Stiffness of gear teeth and the amount of backlash is considered. For the system under consideration, the following assumptions are made:

1. the gears are mounted on the shafts without misalgnment and underbalanced mass and also have the same tooth profile without pitch error.
2. The force between the gear acts upon the path of contact.
3. The lateral vibrations and the variations of the path of contact due to it are ignored.

Hence, for each joint with its following link we can derive the required set of differential equations.

In order to investigate the influence of structured uncertainties and unstructured uncertainties at the dynamic modelling of arm joints, in performance of control, we will consider two other more simply models. In the first model, we consider that there is no backlash in gear pairs, and the gear teeth are not elastic. We take into account only the elasticity of the shafts. In the second model we consider the elasticity of shafts and the amount of backlash.

Now, applying Model Reference Control laws on above models, we will study the behavior of these uncertainties in control performance.

The results of these approaches will be compared and tested on the exact model by simulation.