# DYNAMICS AND CONTROL OF UNDERACTUATED SYSTEMS WITH APPLICATIONS IN ROBOTICS

Ahmad Azlan Mat Isa
Zamri Abdul Rahman
Mohamed Dahalan Mohamed Ramli
Hayder M Assadi Ali
Muhamad Azhan Anuar

Mechanical Engineering Faculty

UiTM, 40450 Shah Alam

Selangor

(email: ahmadazlan@salam.uitm.edu.my)

**KUMPULAN PENYELIDIK**

**AHMAD AZLAN MAT ISA**

**Tandatangan**

Zamri Abdul Rahman

**Tandatangan**

Mohamed Dahalan Mohamed Ramli

**Tandatangan**

Al-
Hayder [redacted] Assadi [redacted]

**Tandatangan**

Muhamad Azhan Anuar

**Tandatangan**

## Abstract

Underactuated systems are mechanical control systems with fewer controls than the number of configuration variables. Control of underactuated systems is currently an active field of research due to their broad applications in Robotics, Aerospace Vehicles, and Marine Vehicles.

The goal to study is to develop a model and control methods for underactauted systems. Although an underactuated manipulator can be structurally identical to a fully actuated one, their dexterities differ because of the presence of unactuated joints. If all underactuated systems in a class can be transformed into a specific class of nonlinear systems, we refer to Artificial Neural Network (ANN) systems as the "normal form" of the corresponding class of underactuated systems.

An adaptive learning algorithm using an artificial neural network ANN has been utilized to predict the passive joint position of underactuated robot manipulator. In this approach a network has been trained to learn a desired set of joint angular positions from a given set of input torque and velocity over a certain period of time. Trying to overcome disadvantages of many used techniques in the literature, the ANNs have a significant advantage of being model-free method. The robot can directly determine the position of its passive joint, and can, therefore, completely eliminate the need for any system modeling.

Even though it is very difficult in practice, data used in this study were recorded experimentally from sensors fixed on robot's joints to overcome the effect of kinematics uncertainties presence in the real world such as ill-defined linkage parameters and backlashes in gear trains. An ANN modal was trained using the experimentally obtained data and then used to predict the path of the passive joint that is positioned by the dynamic coupling of the active joint. The generality and efficiency of the proposed algorithm are demonstrated through simulations of an under-actuated robot manipulator, finally the obtained results were verified experimentally.

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