Intelligent Satellite Control

Samsul Bahari Mohd Noor, Norman Mariun and Mohammad Nizam Fillipski Abdullah

Faculty of Engineering
Universiti Putra Malaysia
43400 UPM, Serdang, Selangor
Malaysia

Telephone Number of Corresponding Author: 03-89466320
E-mail of Corresponding Author: samsul@eng.upm.edu.my

Key words: intelligent control, LEO satellite, attitude control, fuzzy logic, artificial intelligent

Introduction

Satellites today provide society with everything from environmental scientific data to global telecommunications services. The field of satellite design has undergone many changes since its inception at the dawn of the space age in the late 1950's. The attitude control subsystem is a crucial part in a satellite that aims to satisfy maneuvering and pointing requirements of the sateliite payload. It is the pivotal subsystem of a satellite. At the beginning of satellites going into orbit, attitude control is a big problem and satellite usually tumbled because of the disturbances created after disassociation of the satellite with the rocket. The attitude control system must be able to use up the energy of the satellite body immediately in order to stabilize the satellite in the state of proper earth-oriented equilibrium. Moreover, in orbit, the dynamical variable nature of the space environment will create unknown perturbations acting on the satellite orbit and attitude. Some of these disturbances have a greater effect on LEO satellites (like aerodynamic drag), since their magnitude is a function of the distance between the satellite and the Earth. The control of the satellite attitude means either to keep the satellite stable in its desired orientation or to maneuver it from one to another pointing direction.

The type of control required is dependent on the mission of the satellite. Intelligent control brought substantial contribution to complex, nonlinear, time varying, stochastic and ill defined control problems. It was defined as an approach to generate control signal by utilizing artificial intelligence, operational research, computer sciences, approximation theory, and control systems theory. Intelligent control is not defined in terms of specific algorithms (although some researchers said so) but uses a method that can sense and make reasoning concerning its environment (without a priori detailed knowledge), and control the system in a flexible, adaptive and robust manner.

Materials and Methods

In the early stage of the intelligent control development, researchers focused their attention to the method called expert system, but the major trend is currently towards the so called soft-computing or computational intelligence that proved its ability to solve many industrial control problems. The backbones of this method are fuzzy logic, neural networks (NN), and genetic algorithms (GA).

Since a fuzzy system can be tuned to approximate any nonlinear dynamic system, a fuzzy control technique can be used to efficiently eliminate the plant uncertainties, via an adaptive learning method. Fuzzy systems have been extensively used in modeling human-based experts to "copy" their expertise on controlling a plant, such as a flexible arm structure, a vessel automatic docking, or a palm oil crystallization process. A fuzzy controller consists of three distinct sections: the fuzzyfication block (in which the membership degree is calculated), the inference engine and the defuzzyfication block. Inputs to the fuzzyfication block are signal error and error rate, which are modified into fuzzy logic representation. Then, some mathematical manipulations can be done in the inference engine. The result is the control action. This signal being still in a fuzzy logic representation must go through the defuzzyfication process before being applied to the actuator

Results and Discussion

The problem to control the non-linear satellite attitude system with unknown or uncertain inertia matrix and external disturbances is considered. The adaptive fuzzy approximation method is used to estimate an uncertain nonlinear model of the system. A mixed H_2 / H_∞ is used to design an attitude controller based on the designed system. The H_2 approximation is applied to find optimal performance of the system, while H_∞ approximation is applied to find robustness characteristic of the system to external disturbances. The effect of external disturbances and uncertainties on the spacecraft attitude can be restrained and the tracking error as well as the consumed energy of the controller is minimized.

Conclusions

The model-based approach that believes to the power of differential equation modeling and its control design methodology should be applied as far as it is possible. It is true especially for problems where the mathematical model and the system environment are well defined. If it is not the case (and so many control problems show that it is the case), intelligent control methodology could be used. Several issues such as stability already solved in intelligent control methodology, so the limitation of application no longer valid.

Benefits from the study

A new control technique can be applied to satellite attitude control. A series of discussions with Astronautic Technology Sdn. Bhd. has been carried out for the possibility of applying the control technique to Tiungsat-1 as well as an alternative control strategies for Tiungsat-2 which is under development.

Patent(s), if applicable:
Nil

Stage of Commercialization, if applicable:
Nil

Project Publications in Refereed Journals
1. Heltha F, Fillipski MN, Mohd Noor SB, and Mariun N. 2003. Low Earth Orbit Satellites: A Review of Attitude Control Methods. Submitted to Elektrika, affiliated journal of IEEE.

Project Publications in Conference Proceedings:
Nil

Graduate Research

Name of Graduate	Research Topic	Field of Expertise	Degree Awarded	Graduation Year
Ouhochine Cherif	Control of Small Satellite	Aerospace Enegineering	Thesis submitted	

IRPA Project number: 09-02-04-0153
UPM Research Cluster: SAE