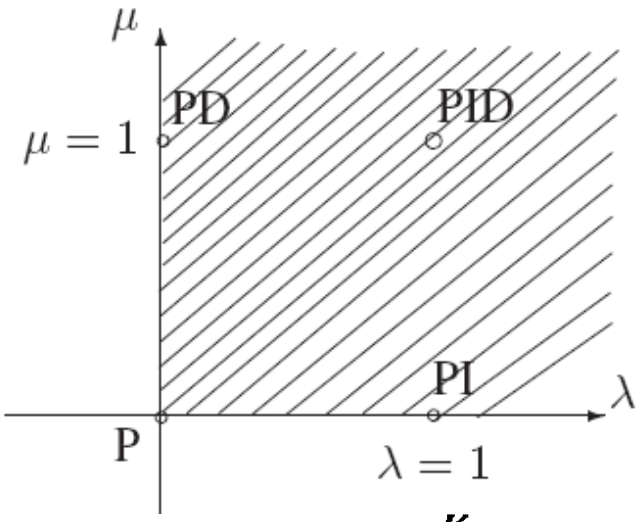
2009 American Control Conference

WeC02 Tutorial Session, Grand Ballroom B (east)

Applied Fractional Calculus in Controls



$$G_c(s) = K_p + \frac{K_i}{s^\lambda} + K_d s^\mu$$

Fractional-order proportional, integral and derivative controller (FO-PID)

Why Fractional Calculus? Many real dynamic systems are better characterized using a non-integer order dynamic model based on fractional calculus or, differentiation or integration of non-integer order. Traditional calculus is based on integer order differentiation and integration. The concept of fractional calculus has tremendous potential to change the way we see, model, and control the nature around us. Denying fractional derivatives is like saying that zero, fractional, or irrational numbers do not exist.

In the control side, clearly, for closed-loop control systems, there are four situations. They are 1) IO (integer order) plant with IO controller; 2) IO plant with FO (fractional order) controller; 3) FO plant with IO controller and 4) FO plant with FO controller. From control engineering point of view, doing something better is the major concern. Existing evidences have confirmed that the best fractional order controller outperforms the best integer order controller. It has also been answered in the literature why to consider fractional order control even when integer (high) order control works comparatively well. Fractional order PID controller tuning has reached to a matured state of practical use. Since (integer-order) PID control dominates the industry, we believe FO-PID will gain increasing impact and wide acceptance. Furthermore, we also believe that based on some real world examples, fractional order control is ubiquitous when the dynamic system is of distributed parameter nature.

The session, through a series of five talks will offer a tutorial of the emerging topic of “Applied Fractional Calculus in Controls” with a snapshot of some recent new results. More information can be found at http://fractionalcalculus.googlepages.com/

Structure of the Tutorial Session

The tutorial session consists of 5 talks:

- **16:00-16:40, Paper WeC02.1 (40 min): *Fractional Order Control – A Tutorial*,** by YangQuan Chen, Utah State University, Logan, USA; Ivo Petras, Technical University of

Kosice, Kosice, Slovakia and Dingyu Xue, Northeastern University, Shenyang, China. This talk will offer an overview of the topic “Applied Fractional Calculus in Controls”.

- **16:40-17:00, Paper WeC02.2 (20 min):** ***Fractional-Order [Proportional Derivative] Controller for Robust Motion Control: Tuning Procedure and Validation,*** by Ying Luo and YangQuan Chen, Utah State University. This talk will describe FO[PD] controller in the form of $K_{p3}[1 + K_{d3}s]^{\mu}$ (<0μ<2) with a tuning method and experiments for a simple servo.

- **17:00-17:20, Paper WeC02.3 (20 min):** ***Fractional Order Networked Control Systems and Random Delay Dynamics: A Hardware-In-The-Loop Simulation Study,*** by S. Mukhopadhyay, Y. Han and Y.Q. Chen of Utah State University. This talk will show how fractional order controller could be beneficial in a networked control system setting.

- **17:20-17:40, Paper WeC02.4 (20 min):** ***Robust Path Planning for Mobile Robot Based on Fractional Attractive Force,*** by Pierre MELCHIOR, Brahim METOUI, Slaheddine NAJAR, Mohamed Naceur ABDELKRIM and Alain OUSTALOUP of Université Bordeaux 1. The talk will describe how fractional notion can be used to perform better in path planning for mobile robots.
- **17:40-18:00, Paper WeC02.5 (20 min):** ***Solution of Fractional Order Optimal Control Problems Using SVD-Based Rational Approximations***, by Y. Han and Y.Q. Chen of Utah State University. This talk will describe how to numerically solve fractional order optimal control problems (FOCPs) of a general form using RIOTS_95, a Matlab toolbox for solving general (integer-order) optimal control problems (OCPs).