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A collection of articles about measurement and control systems in the process industries.

Nanobalance: An automated interferometric balance for micro-thrust measurement

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Abstract

The paper is concerned with a new instrument, nanobalance, measuring thrust and noise of space micro-thrusters in the range 1-1 mN with submicronewton accuracy. Low-noise micro-thrusters will be essential for upcoming "drag-free" space missions like GOCE, SMART-2, LISA, and Darwin. Nanobalance departs from traditional thrust measuring concepts so as to exploit sensitivity of in-vacuum Fabry-Perot interferometers to subnanometric displacements. That is achieved by an optical cavity embraced by two equal pendulums suspended at a constant distance, one of which carrying the micro-thruster under test. Any thrust, changing the optical path length of the injected laser beam, is detected as the frequency variation restoring a standing wave in the cavity. The paper presents the measurement principles, the error budget as derived from recent tests as well as instrument automation, which is essential for facilitating instrument setup and adaptation from measurement trial to trial. The authors are responsible for instrument automation and measurement processing.

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Calculation of the virtual current in an electromagnetic flow meter with one bubble using 3D model

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Abstract

Based on the theory of electromagnetic induction flow measurement, the Laplace equation in a complicated three-dimensional (3D) domain is solved by an alternating method. Virtual current potentials are obtained for an electromagnetic flow meter with one spherical bubble inside. The solutions are used to investigate the effects of bubble size and bubble position on the virtual current. Comparisons are done among the cases of 2D and 3D models, and of point electrode and

large electrode. The results show that the 2D model overestimates the effect, while large electrodes are least sensitive to the bubble. This paper offers fundamentals for the study of the behavior of an electromagnetic flow meter in multiphase flow. For application, the results provide a possible way to estimate errors of the flow meter caused by multiphase flow.

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Differential strain measurement using multiplexed fiber Bragg grating sensors

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Abstract

We investigate differential measurement of strain using fiber Bragg gratings and spatial demultiplexing methods. Differential measurement is shown to improve strain resolution in the presence of noise by an average of 34% compared to absolute measurements of the Bragg wavelengths. Spatial demultiplexing of the gratings provides potentially high-resolution sensing without calculating the sensor wavelengths. The differential method is still temperature dependent. We apply the differential technique to the problem of oil-water boundary detection in production columns, with promising preliminary results.

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Friction identification in mechatronic systems

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Abstract

Since no universal friction model exists and the practical measurement of friction is not straightforward, this paper presents an experimental method of identifying friction in mechatronic systems. Friction is perhaps the most important nonlinearity that is found in any mechatronic system of moving parts and influences the system in all regimes of operation. For the purpose of improving the performance of mechatronic systems and solving their servo problem, a better understanding of friction behavior in its two basic regimes is needed. In this paper, the two basic friction regimes, viz., presliding with its hysteresis behavior, which is predominantly position dependent, and gross sliding, which is predominantly velocity dependent, are well exposed and identified.

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Reinforcement learning algorithms for robotic navigation in dynamic environments

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Abstract

The purpose of this study was to examine improvements to reinforcement learning (RL) algorithms in order to successfully interact within dynamic environments. The scope of the research was that of RL algorithms as applied to robotic navigation. Proposed improvements include: addition of a forgetting mechanism, use of feature based state inputs, and hierarchical structuring of an RL agent. Simulations were performed to evaluate the individual merits and flaws of each proposal, to compare proposed methods to prior established methods, and to compare proposed methods to theoretically optimal solutions. Incorporation of a forgetting mechanism did considerably improve the learning times of RL agents in a dynamic environment. However, direct implementation of a feature-based RL agent did not result in any performance enhancements, as pure feature-based navigation results in a lack of positional awareness, and the inability of the agent to determine the location of the goal state. Inclusion of a hierarchical structure in an RL agent resulted in significantly improved performance, specifically when one layer of the hierarchy included a feature-based agent for obstacle avoidance, and a standard RL agent for global navigation. In summary, the inclusion of a forgetting mechanism, and the use of a hierarchically structured RL agent offer substantially increased performance when compared to traditional RL agents navigating in a dynamic environment.

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Fuzzy logic sliding mode control for command guidance law design

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Abstract

Recently, the combination of sliding mode and fuzzy logic techniques has emerged as a promising methodology for dealing with nonlinear, uncertain, dynamical systems. In this paper, a sliding mode control algorithm combined with a fuzzy control scheme is developed for the trajectory control of a command guidance system. The acceleration command input is mathematically derived. The proposed controller is used to compensate for the influence of unmodeled dynamics and to alleviate chattering. Simulation results show that the proposed controller gives good system performance in the face of system parameters variation and external disturbances. In addition, they show the effectiveness of the proposed missile guidance law against different engagement scenarios where the results demonstrate better performance over the conventional sliding mode control.

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A sliding mode control proposal for open-loop unstable processes

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Abstract

This papers presents a sliding mode controller based on a first-order-plus-dead-time model of the process for controlling open-loop unstable systems. The proposed controller has a simple and fixed structure with a set of tuning equations as a function of the desired performance. Both linear and nonlinear models were used to study the controller performance by computer simulations.

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Smith predictor based-sliding mode controller for integrating processes with elevated deadtime

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Abstract

An approach to control integrating processes with elevated deadtime using a Smith predictor sliding mode controller is presented. A PID sliding surface and an integrating first-order plus deadtime model have been used to synthesize the controller. Since the performance of existing controllers with a Smith predictor decrease in the presence of modeling errors, this paper presents a simple approach to combining the Smith predictor with the sliding mode concept, which is a proven, simple, and robust procedure. The proposed scheme has a set of tuning equations as a function of the characteristic parameters of the model. For implementation of our proposed approach, computer based industrial controllers that execute PID algorithms can be used. The performance and robustness of the proposed controller are compared with the Mataušek-Micic' scheme for linear systems using simulations.

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An adaptive pattern based nonlinear PID controller

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Abstract

This paper presents a nonlinear proportional-integral-derivative (PID) controller, combining a pattern based adaptive algorithm to cope with the problem of tuning the controller, and an associative memory to store the parameters, according to different operating conditions. The simplicity of the algorithm enables its implementation in current programmable logic controller technology. Several real-time experiments, carried out in a pressurized tank, illustrate the performance of the proposed controller.

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PID tuning rules for SOPDT systems: Review and some new results

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Abstract

PID controllers are widely used in industries and so many tuning rules have been proposed over the past 50 years that users are often lost in the jungle of tuning formulas. Moreover, unlike PI control, different control laws and structures of implementation further complicate the use of the PID controller. In this work, five different tuning rules are taken for study to control second-order plus dead time systems with wide ranges of damping coefficients and dead time to time constant ratios (D/τ). Four of them are based on IMC design with different types of approximations on dead time and the other on desired closed-loop specifications (i.e., specified forward transfer function). The method of handling dead time in the IMC type of design is important especially for systems with large D/τ ratios. A systematic approach was followed to evaluate the performance of controllers. The regions of applicability of suitable tuning rules are highlighted and recommendations are also given. It turns out that IMC designed with the Maclaurin series expansion type PID is a better choice for both set point and load changes for systems with D/τ greater than 1. For systems with D/τ less than 1, the desired closed-loop specification approach is favored.

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Tuning PI controllers for stable processes with specifications on gain and phase margins

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Abstract

In industrial practice, controller designs are performed based on an approximate model of the actual process. It is essential to design a control system which will exhibit a robust performance because the physical systems can vary with operating conditions and time. Gain and phase margins are well known parameters for evaluating the robustness of a control system. This paper presents a tuning algorithm to design and tune PI controllers for stable processes with a small dead time while meeting specified gain and phase margins. Simulation examples are given to demonstrate that the proposed design method can result, in a closed-loop system, in better performances than existing design methods which are also based on user-specified gain and phase margins.

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An approach to process production reactive scheduling

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Abstract

Process manufacturing has some characteristics that make it different from other types of industry. In practice, there are many examples of process industrial settings where production resources are shared and there is no intermediate storage between two processing units. Perhaps the most important issue usually to be excluded from the academic discussion of process production scheduling/control problems is the uncertainty of the duration of real chemical processes. These properties of process manufacturing result in blocking, no-wait, and other constraints that must be taken into account during designing the production scheduling system. The first part of the paper addresses some features of process manufacturing and their influence on production scheduling. The main part of the paper analyzes the scheduling problems under the presence of typical process constraints and unpredictable process duration times and introduces a simple and reliable approach to avoid these problems. The proposed concept is presented on a case study of an industrial two-stage washing batch subprocess. It is considered that the presented approach would be relatively easy to implement in a process production scheduling system and that it can contribute to more effective process production scheduling.

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