Editorial: dealing with stability and nonlinearity issues

N.P. Mahalik*

California State University,
Fresno, CA 93740-8002, USA
E-mail: nmahalik@csufresno.edu
*Corresponding author

Mo M. Jamshidi

University of Texas at San Antonio,
San Antonio, TX 78249-0665, USA
E-mail: Mo.Jamshidi@utsa.edu

Biographical notes: N.P. Mahalik received his BS, ME and PhD in the year 1989, 1993 and 1998, respectively. He completed his Postdoctoral Research in 2002 and worked as an invited faculty in Moscow State Technological University, Russia, Gwangju Institute of Science and Technology (GIST), South Korea between 2001 and 2004, respectively. He has published more than 80 papers and five books. He served as Editor, Guest Editor, Committee Member in several journals and conferences. He has been the recipient of National Overseas Scholarship and Brain-Korea fellowships for pursuing research especially in the field of interdisciplinary areas. He has been associated with many professional societies including ISTE, ASABE, ISA, NAIT and IEE.

Mo M. Jamshidi (F-IEEE, F-ASME, F-AAAS, F-NYAS and F-TWAS) received a PhD in Electrical Engineering from the University of Illinois at Urbana-Champaign in 1971. He received three honorary Doctorate Degrees and is Lutcher Brown Endowed Chaired Professor at the University of Texas System at San Antonio Campus, San Antonio, TX, USA. He is the Founding Director of Center for Autonomous Control Engineering (ACE) at the University of New Mexico (UNM) and the Director of the National Consortium on System of Systems Engineering. He has over 550 technical publications including 58 books and edited volumes. He is the Founding Editor/Co-editor of five journals and one magazine.

Most industrial processes are still controlled by PID controllers due to their simplicity, low cost and effectiveness for linear systems. The controllers are normally not suitable for controlling higher order systems, non-linear systems and complex and vague systems without precise mathematical models. However, such processes can be effectively controlled via fuzzy logic. Fuzzy controllers can be linear or non-linear. Non-linearity of the simplest fuzzy PI controller with different inference methods are discussed in the first paper. Analytical structures of the simplest fuzzy PI and PD controllers have been derived using different combinations of t-norms, t-co norms (maximum and bounded sum) and inference methods. Moreover, BIBO stability issue of non-linear fuzzy PI/PD control systems has also been studied. Nowhere in the literature do we find analytical structures for fuzzy two-term (PI/PD) controllers based on algebraic sum t-co norm. In the first paper, analytical structures for the simplest fuzzy PI/PD controllers are derived via symmetric Γ-type and L-type membership functions for inputs, symmetric triangular membership functions for output, minimum t-norm, algebraic sum t-co norm, linear control rules, Mamdani minimum/Larsen product/drastic product inference method, and centre of sums method of defuzzification. Properties of these controllers are investigated to examine their suitability for control application. Sufficient conditions for BIBO stability of a feedback system, containing any one of the proposed fuzzy controllers as a subsystem, are established. The final simulation results of some examples are included to demonstrate the superiority of fuzzy two-term controllers over their conventional counterparts.

Coordination of a group of mobile robots in desired formations requires an integration of motion planning and control strategies. The authors of the second paper have addressed some important issues in the robotic formation problem including initialisation, path planning and decentralised control. Especially an architecture combining virtual structure and leader following techniques has been proposed. The robots are initialised using a new virtual robot tracking and $l-l$ control framework to establish an arbitrary formation without singularities involved and inter-robot collision. Further, the path planning was performed using the modified A* search. Trajectories were obtained based on the predefined formation configuration, given the fact that obstacles must be avoided by adjusting trajectories. A decentralised control approach is proposed to implement global feedback controllers, with the use of linear functional observers, for driving commands of the robot actuators. Simulation and experimental results are provided.

Among different pairing methods for MIMO plants, balanced realisation one has the advantage of considering controllability and observability of the pairs. An automatic algorithm was introduced by the author for this type of pairing. In this paper, the algorithm is applied to a 6×6 plant. To investigate the quality of it, an energy-based performance measure is computed. For impulse response of each output, the ratio of the energy induced by its paired input to the total energy induced by all other inputs is obtained. The average of this ratio over all the outputs is a measure of pairing performance. Higher value of it means better pairing for the plant. Four different pairing sets are compared using the above measure. For each pairing set, a decentralised PD controller is designed. It is shown that the total energy necessary to control the plant using the proposed pairing method is lower than other three alternative pairings. Also, the stability region for the optimal pairing is wider than the others.

Railway traction applications reflect to some extent the modern advances in power electronics and motor drives. In urban metro or limited distance applications, the power supply is invariably dc with the help of trolley wire or a third rail. In such application, dc motors have traditionally been used. In traction applications, the drive should have four-quadrant capability, i.e., it must regenerate in both forward and reverse rotations. In the present paper, a mathematical model of the PWM DC-DC 4-Q (class E) converter driven DC S.E. motor is developed. The model is useful for electric drives designers for the investigation of both normal and abnormal modes of operation of the drive.

It seems, design and analysis on PID controllers will never end. In the avenue of robust control one of the activities has been focused on structured and unstructured uncertainties with dynamic perturbations. The controller is a solution to linear equations in the ring of proper and Hurwitz-stable rational functions. Usually, the controller is obtained via optimisation of nominal closed loop poles and the structured singular value denoted as μ is used for the assessment of robust performance and stability. As an optimisation tool, an evolutionary algorithm, Differential Migration, is used in order to overcome the problem of multimodality of the cost function. Final controllers are compared with the *D-K* iteration as a standard method for μ-synthesis. In this paper, design and analysis of controller with PID structure for SISO plant is performed.

In the next paper, a new approach to the identification of time-varying Wiener systems is presented. The linear dynamic block of the Wiener model is given by its transfer function and the non-linear static block is approximated by a polynomial. The identification is based on a special form of Wiener model, which is linear in parameters. The proposed algorithm is a direct application of the known recursive least squares method extended with the estimation of internal variable values. An illustrative example shows that the estimates of both the linear and the non-linear block parameters follow the true ones and their changes.

In the technical process, any kind of malfunction is understood as a fault. It leads to an inappropriate eccentricity in the overall system performance. Fault may occur in the sensors, actuators or in the component in the process. The main interest in the design of fault detection scheme is detection performance that is the ability to detect and identify failures promptly and correctly with minimal delays. Sensing acoustic emission signals from a machining process is one of the most promising methods suitable for condition monitoring. In this paper, acoustic signals are monitored during rough, finish and plateau honing of cylinder liner using fresh and completely worn out honing tools. The parameters such as root mean square, peak to peak, skewness and kurtosis and dominant frequency in the power spectrum are analysed. The results show that the dominant frequency in the power spectrum is very sensitive to honing tool conditions and a good correlation exists with honed surface quality.

There have been several recent studies concerning stability and state estimation for non-linear systems. Many of these studies use the Lyapunov method and Linear Matrix Inequalities (LMI) formulation concerning T-S fuzzy models with known inputs. In this paper, however the authors consider the design of a fuzzy observer for a non-linear system with unknown inputs described by a fuzzy model. The main objective is to estimate state variables of the fuzzy model subject to unknown inputs which influence states and outputs of the system simultaneously. Using the Lyapunov method and LMI, sufficient conditions are proposed to design the proposed unknown input fuzzy observer. The pole placement in an LMI region is also considered. The validity of the proposed methodology is illustrated by an academic example.

Once again, robust adaptive control of non-linear systems has become the active object of much recent interest. Paper ten considers the design of disturbance observer based on RBF neural network and applies to design synchronisation controller for a class of chaotic systems. The error of the compound disturbance observer is bounded under the given parameter's update law. The designed synchronisation controller can make the synchronisation error convergent to zero. The simulation results demonstrate the availability of the proposed synchronisation control method.

The final paper of this issue further raises the questions concerning the unstable linear plants. The objective was to develop a new systematic approach for design of controllers. The approach is validated in terms of designing an new controller algorithm, and it is based on a 2-layer optimisation: first the optimisation for a given set of values for the pole locations of the lucid coprime factors, a suboptimal design is obtained and the objective function is evaluated, then in sequel a SIMPLEX optimisation approach is utilised to optimise the pole locations of the lucid coprime factors. It has been demonstrated that the new design is simpler to implement and it becomes closer to satisfy the model-matching performance measure.