Editorial

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Control theory is an interdisciplinary branch of engineering and mathematics that is concerned with the behaviour of dynamical systems with inputs, and how to modify the output by changes in the input using feedback, feedforward, or signal filtering. Linear control systems obey the superposition principle. Nonlinear control theory covers a wider class of systems that do not obey the superposition principle. Thus, the nonlinear control models are directly applicable to more real-world systems, because all real control systems are nonlinear. These real-world control systems are often governed by nonlinear differential equations. Stability theory of control systems is often investigated via phase plots, linearisation, bifurcation analysis, Lyapunov stability theory, etc.

Many control methods have been studied to investigate nonlinear control models and automation such as active control, adaptive control, backstepping control, fuzzy logic control, sliding mode control, etc.

This special issue focuses upon the modelling and engineering applications of nonlinear control systems.

It is hoped that this special issue will provide a useful reference for informing recently developed technologies in nonlinear control systems.

The contents of the selected seven articles are described briefly as follows:

The paper titled 'A new conservative chaotic dynamical system with lemniscate equilibrium, its circuit model and FPGA implementation' by Sundarapandian Vaidyanathan, Esteban Tlelo-Cuautle, P.S. Godwin Anand, Aceng Sambas, Omar Guillén-Fernández and Sen Zhang announces a new conservative chaotic dynamical system with lemniscate equilibrium. Since the proposed chaotic system has an infinite number of equilibrium points, it is noted that the new 3-D nonlinear plant exhibits hidden attractors. It is also established in this work that the new conservative chaotic system exhibits multi-stability and coexisting attractors. A circuit model using MultiSIM and FPGA implementation of the new conservative nonlinear plant with lemniscate equilibrium are successfully carried out for enhancing practical implementation in real-world control applications.

The paper titled 'Three-level (NPC) shunt active power filter based on fuzzy logic and fractional-order PI controller' by Sihem Ghoudelbourk, Ahmad Taher Azar and Djalel Dib proposes a three-level neutral point clamped (NPC) shunt active power filter which injects into the network a current equal to that absorbed by the polluting load, but opposed to the phase. The proposed three-level NPC inverter hysteresis-based control shunt active power filter offers enormous advantages compared to the two-level inverters. The regulation and the stability of the DC voltage across capacitor of the power supply filter during in transient states and under various operating conditions is ensured by fuzzy

logic controller and then by a fractional order proportional integral (PI) controller. A comparative study was carried out in detail and the comparison criteria are the total harmonic distortion (THD) in the current line and the stability of the voltage during the load variation. A detailed study of simulation results is presented and discussed to show the performance of this control strategy by a fractional order PI controller.

The paper titled 'H_∞ performance analysis and switching control design for uncertain discrete switched time-delay systems' by Hao-Chin Chang, Chang-Hua Lien and Ker-Wei Yu study the H_∞ performance analysis and switching control of uncertain discrete switched time-delay systems with linear fractional perturbations. The design of a simple switching signal is developed in this work to acquire LMI conditions which achieve H_∞ performance and switching *control* of discrete switched time-delay system. The conservativeness of obtained results can be further improved by using the delay-partitioning approach. Finally, some numerical examples are shown to illustrate the major improvement of the developed results.

The paper titled 'Occasional stabilisation of limit cycle walking and control of chaos in the passive dynamics of the compass-gait biped model' by Hassène Gritli deals with the stabilisation of limit cycles of the passive dynamic walking of the compass-gait model and then the control of chaos. A new stabilisation process of the limit cycle walking is developed based on self-detection of the fixed point of the (un)stable limit cycle and on energy shaping-based trajectory-tracking controller. The control process is applied in the beginning of the swing stage during a desired short time interval making hence the compass-gait biped robot to be completely passive on the remaining swing phase. The paper shows also that the proposed control method allows the compass-gait biped robot to walk efficiently and with a periodic gait down sloped surfaces of different angles.

The paper titled 'Machine learning-based novel DSP controller for PV systems' by Subramanya Bhat implements machine learning-based DSP controller in the proposed study. The genetic algorithm (GA) based DSP controller has been designed for enhancing the efficiency of solar PV. In the proposed work, perturb and observe (P&O) technique and GA have been considered to achieve maximum power point and precise control parameters of PID controller respectively. Single DSPTMS320F28377s has been used to implement both P&O and GA and it is demonstrated that the proposed DSP-based hardware model provides better speed, efficiency and reliability than the existing simulation-based controller.

The paper titled 'Optimal control based on multiple models approach of chaotic switched systems, application to a stepper motor' by Yosra Miladi, Nabil Derbel and Moez Feki derives new results in the control of chaotic switched systems with application to a stepper motor. The main objective of the control is to determine the optimal sequence of switching instants in order to bring the chaotic behaviour of the system to a periodic one. The determination of the optimal sequence will follow two steps using an optimisation algorithm, the Hamiltonian system and the derivative of a performance criterion over the switching instants. The nonlinear switched system is modelled by a multiple linear time-invariant models approach to make possible to calculate the gradient of the cost function and therefore to determine the optimal instants of switches. Numerical simulations are applied to a stepper motor to illustrate the results.

The paper titled 'Low power pulsed flip-flop with clock gating and conditional pulse enhancement' by John Kuruvilla, R.S. Vinod Kumar and S.S. Kumar presents the design of a new power-efficient implicit pulse-triggered flip-flop suitable for low power

applications. Two important features are embedded in this flip-flop architecture. Firstly, the enhancement in width and height of trigger pulses during specific conditions gives a solution for the longest discharging path problem in existing P-FFs. Secondly, the clock gating concept reduces unwanted switching activities at sleep/idle mode of operation and thereby reducing dynamic power consumption. The post-layout simulation results in cadence software based on CMOS 90-nm technology shows that the proposed design features less power dissipation and better power delay performance (PDP) when compared with conventional P-FFs. This paper also presents a comparative study on the performance of implicit and explicit pulse flip-flop designs. The maximum power saving of proposed design against conventional implicit and explicit design is up to 18.45% and 58.49% respectively.

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