Plenary Sessions

Hardware/Software Implementation of an Extended Kalman Filter-based PI-/PD-like Fuzzy-Neural-Network Controller for Industrial Drives

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BIOGRAPHY

AHMED RUBAAI received the M.S.E.E degree from Case Western Reserve University, Cleveland, OH, and the Dr. Eng. degreefrom Cleveland State University, Cleveland, OH, in 1983 and 1988, respectively. In 1988, he joined Howard University, Washington, DC, as a faculty member, where he ispresently a Professor and Chairperson of the Electrical Engineering and Computer Science Department.Dr. Rubaai has been named an IEEE Fellow in 2015. As a researcher, Dr. Rubaai has made significant contributionsto the development and control of electric motor drives for industrial system applications in a variety of roles including: scientist, research engineer, university professor, and as IEEE volunteer and leader. The large majority of these contributions are heavily oriented towards industrial applications that IEEE serves. Of particular importance is his development of control technologies by way of intelligence; laying the technological foundations for the production versions of high-performance drives used in an expansive array of industrial, commercial, and transportation applications today. His work covers a broad range of manufacturing and product applications and exemplifies his ability to bridge between academic research and the application to industrial applications.The bridges that Dr. Rubaai has built between industry and academia represent a uniquely valuable contribution that can be matched by very few others in the academic world today.

As an Educator, Dr. Rubaai has been an acknowledged educator and leader of curriculum development at Howard University for more than two decades. He is the Founder and Lead Developer of Motion Control and Drives Laboratory (http://www.controllab.howard.edu) that provides engineering students with valuable hands-on and "real-world" experiences." In recognition of his scholarly work and dedication to the improvement of engineering education, his work is recognized by the larger community of engineering educators, as verified by his receipt of the 2011 ASEE Robert G. Quinn Award and the Distinguished Educator Award of the Middle-Atlantic Section of the American Society for Engineering Education. This recognition is a clear demonstration and confirmation of his peers' high regard for his contributions to engineering education.

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ABSTRACT

This talk presents the development and experimental implementation of a fuzzy-neural-network (FNN) proportional-integral (PI)-/proportional-derivative (PD)-like controller with online learning for speed trajectory tracking of an industrial drive system. The FNN combines fuzzy logic (FL) with the learning capabilities of an artificial neural network. The design implements the novel use of the extended Kalman filter (EKF) to train FNN structures as part of the PI-/PD-like fuzzy design. The FNN structure has two parallel FNN PI-/PD-like controllers, each with four internal layers. EKF trains each FNN by modifying the weights and the membership function parameters. Hence, the proposed EKF-based architecture presents an alternative to control schemes employed so far. The tangible is to replace the conventional PI-derivative (PID) controller with the proposed FNN PI-/PD-like controller with EKF learning algorithm. Comparisons of the algorithm performances provide evidence of improvement of the FNN PI-/PD-like controller over PID control.The presence of adaptive control via the EKF learning of the FNN control laws marks an improvement over the FL design. The benefits of the adaptive control providing access to the fuzzy rules online and the proper execution of the updates are improved control law maintenance operations.

Experimental implementation of the EKF learning algorithm is achieved via dSPACE DSP MATLAB/Simulink environment and allowed for the capability for adaptive self-tuning of the weights and memberships of the input parameters. Therefore, this adds a self-learning capability to the initial fuzzy design for operational adaptively and implements the solution on real hardware using a BLDC motor drive system. The success of the adaptive FNN-controlled industrial drive system is verified by experimental results.