New Control Strategy for Doubly Fed Wind Schemes

Adel Sharaf[1] and Mohammed Abouheaf[2]

[1] SHARAF Energy Systems, Inc., Fredericton, New Brunswick, Canada

[2] School of Electrical Engineering and Computer Science, University of Ottawa, Ottawa, Ontario, Canada

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The unceasing consumption of the fossil fuels has contributed to serious environmental problems like global warming. The repercussions urged the scientific societies and their industrial partners to adopt challenging and clean technologies to drastically limit the use of the traditional energy sources. This is associated with considerable regulatory and technological challenges due to the high nonlinearity, integrity, and complexity of the power grids. The wind energy utilization schemes are emerging as viable cost effective alternative energy sources in the electric utility generation mix with production cost of about $2000 / KW and energy cost of $0.06-0.08 / KWh. Large scale wind farms are currently utilized with capacities ranging from 100-600 MW. The accuracy of the dynamic models for the wind schemes along with their model-based controllers play a crucial role in maximizing the energy conversion efficiency for the wind schemes. The lack of having robust modeling approaches is a major challenge in designing control systems for the renewable energy units which in many types have uncertain and fast varying dynamics. The talk employs some ideas from the optimal control theory and machine learning fields to solve the challenging model-free control problem of the doubly fed wind schemes.

Reinforcement Learning is an area of machine learning concerned with how an agent can pick its actions in a dynamic learning environment to transit to new states in such a way that minimizes the cumulative sum of an objective cost function. The reinforcement learning approaches allow the development of algorithms to learn online the solutions to optimal control problems for dynamic systems that are described by difference equations. These involve two-step processes known as policy iteration or value iteration. The reinforcement learning algorithms are implemented online using means of the actor-critic neural networks. These approximations are temporal difference methods with separate structures that explicitly represent the policies apart, from the value structures. These structures involve forward-in-time algorithms for computing optimal decisions that are implemented online in real-time. The actor component applies the approximated control strategies to their environment, while the critic rewards some decisions and penalizes some other decisions. Based on this assessment, the actor policy is updated at each learning step.

The control problem of the doubly fed double rotor large scale induction generators driven by wind turbines is challenging due to the high nonlinear characteristics and the stochastic variations in the input-output conditions of the wind turbines. The modeling and control approaches of the wind turbines do not take into consideration the prevailing uncertainties in the dynamics, which could lead to severe degradation in the isolated and grid-connected modes of operation. Model-free adaptive learning approaches are developed to solve the challenging control problem of the doubly fed wind schemes which operate in uncertain dynamical environment. This approach finds the optimal control solution by solving the respective Bellman optimality equation in real-time. Unlike the traditional machine learning approaches, the adaptive learning approaches are easily implemented online without spending any extensive computing effort and it is robust against the large variations in the dynamics of the wind turbines.

=====================Bio -- Dr. Sharaf =====================

Dr. Sharaf obtained his B.Sc. degree in Electrical Engineering from Cairo University in 1971. He completed a M.Sc. degree in Electrical engineering in 1976 and Ph.D. degree in 1979 from the University of Manitoba, Canada and was employed by Manitoba Hydro as Special Studies Engineer, responsible for engineering and economic feasibility studies in Electrical Distribution System Planning and Expansion. Dr. Sharaf was selected as NSERC-Canada Research-Assistant Professor in 1980 at University of Manitoba. He joined the University of New Brunswick in 1981 an Assistant professor and he was promoted to Associate Professor in 1983, awarded tenure in 1986, and the full professorship in 1987. Dr. Sharaf has extensive industrial and consulting experience with Electric Utilities in Canada and Abroad. He is the President & Technical Director of both Sharaf Energy Systems Inc. & Intelligent Environmental Energy Systems, Canada Inc. of Fredericton, New Brunswick, Canada.

He authored and co-authored many Book chapters, Over 700 Scholarly Technical Journal, Referred Conference Papers and Engineering Reports. In power systems control, stability, protection, power quality, renewable green-energy, electro-technology and environmental devices He supervised over (51) Graduate Student (37-M.Sc &14-Ph.D.) since joining Academia in July-1981. His research interests include Smart Grid, Emerging Energy systems, Power Systems and Electrochnology, FACTS Control, Protection, HVDC Transmission, Renewable/Alternate Energy/Storage Systems, Electric Motor Drives, Harmonics and Power Quality, Protection, Industrial Electronics, Power Electronics, A.I-Soft Computing. (PSO, fuzzy logic, neutral networks, genetic algorithms applications in electrical systems), Multimedia/Internet based Learning, Computer Based Learning(CBL), Self-Based Learning (SBL),Laboratory Based Learning, Electrical Apparatus & Systems & Energy Delivery, Electrical Measurements, Energy Efficiency, Electric Utility Grid Systems (Planning, Operation, Control & Protection and Security) and Pollution Abatement devices & Systems.

=====================Bio -- Dr. Abouheaf ===================

Dr. Abouheaf obtained his B.Sc. and M.Sc. degrees in Electronics and Communication Engineering from Mansoura University, Egypt, in 2000 and 2006 respectively, and his Ph.D. degree in Electrical Engineering from University of Texas at Arlington, Texas, USA in 2012. He worked as Adjunct Faculty with the Electrical Engineering Department, University of Texas at Arlington. He was a member of the Advanced Controls and Sensor Group (ACS) and the Energy Systems Research Center (ESRC), University of Texas at Arlington. He is currently with the School of Electrical Engineering and Computer Science, University of Ottawa, Canada. He is author of numerous book chapters, journal, and referred conference papers in the fields of applied mathematics, systems and controls, renewable energy, optimization theory, and heuristics. He received the 2016 best paper award from the journal of control theory and technology. He supervised graduate students who worked on the adaptive intelligent algorithms and control schemes for the distributed generation systems, unmanned aerial vehicles, distributed autonomous systems, and multi-robot path planning.