Overcoming Control Complexity of Constrained Three-link Manipulator Using Sliding-mode Control

For the category of constrained three-link manipulation robots, it is shown how the complexity of controlling anthropomorphic arm-like manipulators can be considerable ameliorated by designing a sliding-mode control. First, a representation singular system model of three-link manipulators is established by employing constrained equations and corresponding descriptions of force restriction. Then sliding-mode control with constrained control inputs for three-link manipulator is expatiated as appropriate. Based on quadratic performance index, then the optimal sliding mode switching function for three-link manipulator system is derived and a modified reaching law on the grounds of the singular model is constructed using a power function. In turn, thereafter the sliding mode controller design for the constrained three-link manipulator is accomplished by using the proposed reaching law. Finally, the achievable performance and efficiency of the proposed control method is demonstrated via applying the derived results to the mathematical representation of PUMA-560 and the respective simulation results obtained. On the grounds of these novel achievements it is thus believed that a new manipulator control design that possesses higher quality in comparison with the nowadays the known design solutions has been contributed in this work. The next and final step in this research endeavour is to carry out the necessary experimental investigation of both laboratory- and industrial-scale manipulators.

Keywords—Anthropomorphic arm-like robot; constraints; three-link manipulator; sliding-mode control; singular system.

Brief Professional Bio - Georgi Marko Dimirovski

Dr. Georgi Marko Dimirovski was born on 20.12.1941 in Greece, in village Nestorion – Nestram in Aegean Macedonia. Currently, he is a Research Professor (retired) of Automation & Systems Engineering at St. Cyril and St. Methodius University of Skopje, Macedonia, and a foreign Guest Professor of Computer & Control Sciences at Dogus University of Istanbul, Turkey as well as 'Pro Universitas' Professor of Obuda University in Budapest, Hungary, at the Doctoral School (according to the age limit by the law in Hungary). Also, during previous 5 years he has been teaching to graduate on summer schools at universities in Dalian, Nanjing, Shanghai, and Shenyang in China.

In the year 1994, he was a Senior Research Fellow & Visiting Professor of the Free University of Brussels, Belgium, following the award of the grant "Research in Brussels" by the Ministry of Brussels Capital. Similarly, in the year 2000, Prof. Dimirovski was a Senior Research Fellow & Visiting Professor of Johannes Kepler University of Linz, Austria, following the award of a grant for "Visiting Professorship" by Austrian Federal Ministry of Higher Education. During the last three decades, he has paid longer- or shorter-term academic visits with seminars to universities in: Aalborg, Ankara, Belgrade, Bradford, Bochum, Brussels, Coimbra, Covilha, Duisburg, Grenoble, Hannover, Istanbul, Izmir, Linz, Lisbon, Ljubljana, London, Maribor, Nis, Portsmouth, Sarajevo, Sevastopol, Sofia, Split, Valencia, Wien, Wolverhampton, and Zagreb as well as Beijing, Dalian, Nanjing, Shanghai and Shenyang (CN), and also Kaohsiung (TW).

In 1977 he received his degree "PhD by Research" in Automatic Control from the University of Bradford in Bradford, England, UK for his research carried at the then Postgraduate School of Control Engineering. In 1974 he has obtained his degree M.Sc. in Electrical & Electronic Engineering from the

University of Belgrade, Serbia, and in 1966 his degree Dipl.-Ing. in Electrical Engineering from St. Cyril & St. Methodius University of Skopje, Macedonia.

He has served on the Executive Council of the European Science Foundation (ESF) during 1989-1993, and on the Technical Board of the International Federation of Automatic Control (IFAC) during 2005-2011. He has served as an associate editor for several international journals, but now serves only the Journal of the Franklin Institute. He served three terms as the president of former Yugoslav Association for ETAN, Yugoslav NMO of the IFAC (before the 1991), as well several terms as the president of the ETAI Society, Macedonian NMO of the IFAC. He and a group of collaborators have founded the ETAI Society in June in 1981.

Internationally, he has contributed: one research monograph he edited for Springer International, 17 chapters in monograph, and about 100 journal articles as well as more than 350 papers in the IEEE and IFAC proceedings series alone. He has received a number of international awards among which the most important ones are:
a/. The 2009 IET Premium Award from the UK Institution of Engineering & Technology for the best article of the journal IET Control Theory & Applications in 2008 (along with Dr King-Qui Li and Prof. Jun Zhao).
b/. The 2011 Outstanding Service Award from the IFAC Organization during the 18th World Congress in Milano, Italy.
c/. The Outstanding Associate Editor 2011 of the International Journal of Automation & Computing (IJAC), given by jointly the Board of the IJAC and the publisher Springer.

Currently, his research interests are focused on complex dynamic networks and systems, on applied computational intelligence based on fuzzy-logic and neural-networks, and on switched systems and switching control.