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Enhanced Robust Convex Relaxation Framework for Optimal Controllability of Certain Large Complex Networked Systems

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Keywords: Cyber-physical systems; cyber-physical power system; large complex networked systems; temporal networks; supply chain vulnerability; efficient controllability; strong controllability; control signal energy cost; robust convex relaxation; accelerant arm

Abstract: Efficient Controllability Problems (ECP) for Large Complex Networked System (LCNS) often involve solving a succession of convex optimization problems, with varied approaches to optimally resolve each problem. In various cases, even when the input set is specifically designed/architected to segue to a convex paradigm, the resultant output set may still turn out to be nonconvex. Further processing is necessary to reach the desired convex paradigm, such as via certain relaxation techniques. However, the involved transformation, during the processing, may result in further nonconvex optimization problems, thereby highlighting the need/opportunity to utilize an Enhanced Robust Convex Relaxation (ERCR) framework. In this paper, we illuminate how leveraging such an ERCR framework, to discern how the involved LCNSs topological structure, facilitates or prevents the diffusion of control signals and/or augmented control signals, which in turn informs the computations related to an accelerant amalgam and numerical stability paradigm for effectively leveraging a set of control/driver nodes to influence yet another set of control/driver nodes so as to steer the LCNS to a target state, if a decoupled and sequenced control strategy is utilized. The numerical stability paradigm employed by the ERCR framework is, potentially, of scientific gain and shows promise in contending with certain round-off errors, thereby better facilitating the transformation of certain uncontrollable cases into controllable cases, if temporal networks are considered. For those paradigms, wherein the Bak-Tang-Wiesenfeld (BTW) sandpile cascading effect is a potentiality, this facilitation may be quite significant.

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