Metaheuristic Approaches to Order Reduction of Interval Systems: A New Dimension Of Research

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In the domain of system and control engineering, order reduction of large-scale systems to lower order models has been an important area of research for a lot many years. Continuous stirred tank reactor, robotic manipulator, oblique wing aircraft and etc. are described in mathematical terms with the help of uncertain parameters and are termed interval systems. For the class of interval systems, some arithmetic formulations were developed by Kharitonov. Significant volume of work was also contributed for the order reduction of continuous-time interval systems. Some of the popular methods for reduced-order modelling of interval systems involve differentiation method, factor division method, Cauer second form, moment matching method, Padé and Routh approximation methods. Even mixed methods involving two different classical methods are also dominant in the literature. Usually in the mixed approach, the numerator and denominator polynomials were estimated respectively by two different techniques. On a similar note, parallel methods for the model reduction of interval systems were formulated in the discrete-time domain. However, works on the unified delta domain pertaining to interval systems have not been reported. So, some arithmetic rules can be formulated to describe the modelling of such systems. Added complexities like interval systems with time-delay and non-integer terms can be a good area of research in future. Even study of the model reduction techniques for unstable interval systems are yet to be explored. Metaheuristic algorithms have been pretty consistent in recent times to solve several engineering design problems. Till date several metaheuristic techniques as well as their variants including some hybrid algorithms have already been applied to address model reduction of different types single-input single-output (SISO) systems. While applying a metaheuristic method, some constraints have to be accommodated in the investigation. Inequality constraints can be applied to make the reduced system stable, preserve its minimum phase nature and meet its time and frequency domain measures. Even the constraints for time and frequency domain parameters can also be included as equality constraints for strict compliance. The dc gain of the reduced system must also match that of the parent model. This is also satisfied through an equality constraint. Since the model parameters are represented with the help of a range, separate constraints need to be applied for estimating the parameters of the numerator and the denominator. Thus, metaheuristic approach can be a good choice to perform model reduction of interval systems.

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