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論 文 の 要 約

報 告 番 号	甲 乙 第 224 号	氏 名	伊藤大輔
学 位 論 文 題 目	Bifurcation Analysis and Controlling Chaos with Perturbed Thresholds for Interrupt Dynamical Systems (断続力学系の分岐解析及びしきい値を用いたカオス制御)		

論文の要約
※「目的・問題提起・考察・まとめ」のように論文の構成に沿ったかたちでまとめられたもので，論文の中身が分かるもの

This thesis describes on bifurcation phenomena and controlling chaos in interrupt dynamical systems. Especially, we discuss treatment of switching threshold values.

Systems with switches or impact motions must be modeled as dynamical equations containing jumps or break points. In the preceded studies, we have mainly focused on the bifurcation problem with variations of parameters indicated in the dynamical equations explicitly. Influence of change of threshold values on bifurcation structures is not discussed enough since no one solves bifurcation sets with threshold values as a variable. In fact, derivatives of maps about such implicit parameters are not investigated, thereby bifurcation sets should be obtained by applying brute-force methods.

Firstly we propose a numerical computation scheme to solve bifurcation problems in interrupt dynamical systems by treating threshold values as a variable parameter. Firstly we describe the problem as a two-point boundary value problem with extending a composite map constructed with Poincaré sections attached at the break points or discontinuous instances. To adapt the Newton's method as solver, we derive variations of the composite map. By implementing the chain rule for the derivatives of the map, we obtain all required variations of the Jacobian matrix for Newton's method. We explain the concrete processes of the bifurcation analysis for a discrete-time hybrid system and a continuous-time interrupt dynamical system, and we demonstrate corresponding numerical results. Additionally, we indicate a critical situation that degrades the conversion ability of Newton's method on these analyses, and we propose a way around the situation.

In interrupt dynamical systems, it can be considered that switching threshold values are effective and manageable parameters for adjustment of behavior. As an application of extension, we propose a new controlling chaos procedure with perturbed switching threshold values for interrupt dynamical systems. The key point of this application is to feature a variation of threshold value as an accessible parameter and it is utilized directly to compute a feedback gain systematically. We explain a design procedure of the controller, and we demonstrations some numerical simulations and laboratory experiments for a one-dimensional chaotic circuit.

As a result, we have clarified analysis method by switching threshold values and controlling chaos method with perturbed threshold values for interrupt dynamical systems. Moreover, we have shown critical matters for bifurcation analysis of them, and avoidance techniques have been proposed.

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論 文 内 容 要 旨

報告番号	甲 先 第 224 号	氏 名	伊藤 大輔
学位論文題目	Bifurcation Analysis and Controlling Chaos with Perturbed Thresholds for Interrupt Dynamical Systems (断続力学系の分岐解析及びしきい値を用いたカオス制御)		

内容要旨

A system with nonlinearity shows strange and complex behavior, for example periodic solutions, chaotic attractors, and bifurcation phenomena associated with them are observed. If bifurcation phenomena occur by varying environment parameters of the system slightly, qualitative properties are changed drastically. Therefore the visualization of bifurcation structures explains important information for consideration of behavior or stability of singular points when mathematical models are derived from actual systems. On analyses of bifurcation structures, Kawakami are proposed the computation scheme through Newton's method and Jacobian matrices. They had formulated definitions of periodic solutions and bifurcation phenomena as the two-point-boundary problem, and proposed the procedure to solve them. On the other hand, it is considered that chaotic phenomena cause unexpected irregular motions in some engineering fields. The controlling chaos promoted by OGY and related works established frameworks to stabilize unstable periodic orbits with a tiny control input.

Systems with switches or impact motions must be modeled as dynamical equations containing jumps or break points. In the preceded studies, we have mainly focused on the bifurcation problem with variations of parameters indicated in the dynamical equations explicitly. Influence of change of threshold values on bifurcation structures is not discussed enough since no one solves bifurcation sets with threshold values as a variable. In fact, derivatives of maps about such implicit parameters are not investigated, thereby bifurcation sets should be obtained by applying brute-force methods.

This thesis describes on bifurcation phenomena and controlling chaos in the interrupt dynamical systems. Firstly we propose a numerical computation scheme to solve bifurcation problems in interrupt dynamical systems by treating threshold values as a variable parameter. Firstly we describe the problem as a two-point boundary value problem with extending a composite map constructed with Poincaré sections attached at the break points or discontinuous instances. To adapt the Newton's method as solver, we derive variations of the composite map. By implementing the chain rule for the derivatives of the map, we obtain all required variations of the Jacobian matrix for Newton's method. We explain the concrete processes of the bifurcation analysis for a discrete-time hybrid system and a continuous-time interrupt dynamical system, and we demonstrate corresponding numerical results. Additionally, we indicate a critical situation that degrades the conversion ability of Newton's method on these analyses, and we propose a way around the situation.

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論文審査の結果の要旨

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学位論文題目

Bifurcation Analysis and Controlling Chaos with Perturbed Thresholds for Interrupt Dynamical Systems
(断続力学系の分岐解析及びしきい値を用いたカオス制御)

審査結果の要旨

本研究は，しきい値を変化させた場合の断続力学系における定性的性質の検討と，その応用であるカオス制御について検討している．
しきい値に到達することによりベクトル場が切り替えられる系における周期解について，方程式に陽に現れないパラメータであるしきい値について，その変分を導出し，分岐問題を解いており，新規性は高いと評価できた．
分岐問題の数値計算アルゴリズムにニュートン法を適用する際の，断続系特有の問題についても回避法等を提案しており，解析結果の信頼性も高いと判断される．
また，応用としてしきい値変動型のカオス制御について検討し，理論・数値実験のみならず，実回路においても制御系の実装を行っている．その実験結果も，理論や数値解析結果と合致しており，有効性も確認できた．
本研究は，電子情報通信学会論文誌，International Journal of Bifurcation and Chaos に公表されており，本論文を総合的に評価した結果，博士（工学）の学位授与に値するものと判定する．
なお，本論文の審査には，大分大学高坂拓司准教授の協力を得た．