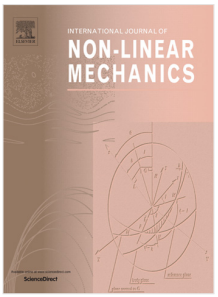

Detecting unstable periodic orbits and unstable quasiperiodic orbits in vibro-impact systems

Yongxiang Zhang, Guanwei Luo

PII: S0020-7462(16)30198-6
DOI: http://dx.doi.org/10.1016/j.ijnonlinmec.2017.07.011
Reference: NLM 2884

To appear in: *International Journal of Non-Linear Mechanics*

Received date : 24 September 2016
Revised date : 23 July 2017
Accepted date : 24 July 2017

Please cite this article as: Y. Zhang, G. Luo, Detecting unstable periodic orbits and unstable quasiperiodic orbits in vibro-impact systems, *International Journal of Non-Linear Mechanics* (2017), http://dx.doi.org/10.1016/j.ijnonlinmec.2017.07.011

Detecting unstable periodic orbits and unstable quasiperiodic orbits in vibro-impact systems

Yongxiang Zhang[a*], Guanwei Luo[b]

[a]*School of Mathematical Sciences, University of Jinan, Jinan, Shandong 250022, China*
[b]*School of Mechatronic Engineering, Lanzhou Jiaotong University, Lanzhou 730070, China*

Abstract

In this paper, unstable dynamics is considered for the models of vibro-impact systems with linear differential equations coupled to an impact map. To provide a skeleton for the organization of chaotic attractors, we propose a method for detecting unstable periodic orbits embedded in chaotic attractors through a combination of unconstrained optimization technique and Poincaré map. Three numerical examples from different vibro-impact models demonstrate that the strategy can efficiently detect unstable periodic orbits in chaotic attractors. In order to explore the mechanism responsible for the creation of multi-dimensional tori attractors, we also present another method to detect unstable quasiperiodic orbits embedded multi-dimensional tori attractors by examining a specially transient time series. The upper bound and lower bound of the transient time series (in the Poincaré map) can be obtained by analyzing transient Lyapunov exponent and transient Lyapunov dimension. Some examples verify the effectiveness of the numerical algorithm.

Keyword: Vibro-impact; nonlinear dynamics; unstable periodic orbit; unstable limit cycle; Poincaré map

1. Introduction

Vibro-impact dynamics has occupied a wide spectrum of studies over the last several decades [1-2]. Vibro-impact dynamics are relevant to many applications including different types of vibro-impact systems such as rotary systems and milling [1-3]. One of the most beneficial outcomes of vibro-impact dynamics is the development of impact dampers. The principle of operation of vibration hammers, impact dampers, machinery for compacting, milling and forming, shakers, offshore structures, etc., is based on the impact action for moving bodies. On the other hand, vibro-impact has detrimental effects on the operations of mechanical systems and damage of fuel elements, e.g., mechanisms with clearances, heat exchangers, rods of nuclear reactors, gears, pipes conveying fluids with end-restraints, wheel-rail interaction of highspeed railway coaches, etc., can bring about failures, strain, shorter service life and increased noise levels. Early studies on vibro-impact dynamics

* ***E-mail address:*** zyx9701@126.com(Y.Zhang）