DSTA 2021 dys-ta.com
16th INTERNATIONAL CONFERENCE
Dynamical Systems – Theory and Applications
December 6-9, 2021, On-line

Method of adaptive bacterial foraging optimization for detection and locating periodic and multi-periodic orbits

ALEXANDER RUCHKIN, CONSTANTIN RUCHKIN *

1. National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute", IASA, Address: 37, Prosp. Peremohy, Kyiv, Ukraine, 03056, alex3005r@gmail.com,

* Presenting Author

Abstract: In this paper we consider the problem of detection periodic and multi-periodic solutions of dynamical systems with a special Hamiltonian structure [1]. The detection of periodic solutions of dynamical systems is carried out by means of an analysis of the Poincaré sections of phase space on the plane for the presence of closed trajectories of a special kind on these sections. In most regular cases, the trajectories under investigation represent special geometric shapes - like circles, an ellipse, etc. To solve the problem of recognizing such forms, it is proposed to use the evolutionary method of bacterial search for stochastic global optimization - adaptive bacterial foraging optimization.

Keywords: The dynamical systems, the Hamiltonian systems, the periodic and quasi-periodic orbits the regular behaviour system, the bacterial foraging optimization

1. Introduction

We consider n-dimensional Hamiltonian system. According to the KAM theory, the system with the Hamiltonian is called integrable, if there is a canonical transformation to a new variable angle. The existence of n integrals of motion means are that a 2n-dimensional phase space of an integrable Hamiltonian path belongs to the n-dimensional set, which has the topology of the n-dimensional torus. On that torus the system trajectory is presented by the winding. If the ratio of the frequencies along the meridians and parallels rationally, the trajectory is closed. If the frequency ratio is irrational, then the trajectory of a dense way fills the surface n-dimensional torus. In this case, the motion is chaotic. Torus on which the winding «not irrational», frequency ratio does not satisfy become unstable and collapse. Also with the destruction of some torus is born smaller tori, which in the Poincare section correspond to elliptic fixed points interspersed with hyperbolic fixed points. The process of destruction of some tori and the birth of other smaller breeds continues self-similar distribution of elliptic and hyperbolic fixed points in the Poincare section. We are interested in automatic detection integrable cases with help numerical researches [1].

2. Results and Discussion

For this we carry out investigations the numerical researches of phase space, which consist of set of not intersected phase trajectories by means of Poincare's sections. Poincare's section, which are constructed in the phase space, have dimensionality on unit is less than dimensionality of researched dynamical system. The exceptional interest the dynamical systems of the third and fourth order is represented. Poincare's sections for such systems will represent certain graphic images on a plane or

in space accordingly. If points of a phase flow are formed a closed curve, then it is possible to speak about the regular behaviour (periodic or multi-periodic) of Hamilton systems. The particular interest is represented by dynamic systems for which there is a possibility of reconstruction and investigation of global Poincare's section. Though creation of section of Poincare of phase space happens approximately by means of integration numerical methods on the fixed interval of time, it appears enough what to understand an overall picture of behaviour of Hamilton system. The received phase portraits of two-dimensional and three-dimensional sections of Poincare of Hamilton systems can be researched by means of automatic pattern recognition techniques.

So, in the integrable cases Poincare section will be of a surface area, which shows a certain type of closed curves: circles, ellipses and other algebraic curves with or without self-intersection. These cases correspond to the regular (periodic or multi-periodic) solution of a nonlinear dynamical system. We use a recently developed swarm intelligence technique, known as the Bacterial Foraging Optimization Algorithm (BFOA) [2] for automatic detecting circle shapes from digital images. We develop an adaptive version of BFOA is then applied to search the entire edge-map for circular shape. Each bacterium here models a trial circle and a fuzzy objective function has been derived over the domain of such trial circles. The better a test shape approximates the actual edge-shape, the lesser becomes the value of this function. Minimization of the objective function with BFOA ultimately leads to the fast and robust extraction of circular shapes from the given image. In the work consider the conditions of applicability of this approach for different geometric forms, which we have classified on the map Poincare. The parameters which the method will give the most optimal result are calculated.

3. Concluding Remarks

In this works for dynamical system [1] with help program Modeler the global spherical Poincaré section are investigated. This section builds a three-dimensional sphere and shows a set of points (point cloud). In regular cases, these sets of points form a three-dimensional «closed curve» with self-crossing or without self-crossing. A particular case of this curve is a circle or ellipse, which lies on the surface of a sphere, with the centre of the circle can pass or not pass through the centre of the sphere.

New program module are develop and integrated to program Modeler. This module are detected and recognised of three-dimensional convex closed analytic curves constructed on the Poisson sphere using the adaptive method of BFOA for all parameters of model.

References

[1] Ruchkin C. The General Conception of the Intellectual Investigation of the Regular and Chaotic Behavior of the Dynamical System Hamiltonian Structure. In: Awrejcewicz J. (eds) Applied Non-Linear Dynamical Systems. Springer Proceedings in Mathematics & Statistics, vol 93. Springer, Cham, 2014, DOI: 10.1007/978-3-319-08266-0_17

[2] S. Dasgupta, S. Das, A. Biswas, and A. Abraham, "Automatic circle detection on digital images with an adaptive bacterial foraging algorithm," Soft Computing, vol. 14, no. 11, pp. 1151–1164, 2010, DOI: 10.1109/TEVC.2009.2021982