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НЕЛИНЕАРНОСТИ И ХАОС У ДИНАМИЦИ ИНЖЕЊЕРСКИХ СИСТЕМА
NONLINEARITY AND CHAOS IN ENGINEERING DYNAMICS

Periodicity, Quasi-periodicity and Chaos: Practical Numerical Analysis

Summary

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Periodic, quasi-periodic and chaotic orbits play a fundamental role in nonlinear dynamical systems. Therefore, a question of systematical tracking such solutions with respect to control parameters starting from equilibrium to periodicity, quasi-periodicity and chaos is necessary to understand (and take control) of global dynamic behaviour of the investigated physical systems.

First, a stability of equilibria are tracked numerically and a Hopf bifurcation is predicted. The eigenvector in a Hopf point shows the direction of a new born periodic orbit. Then this orbit is followed numerically together with the simultaneous calculation of stability. Possible bifurcation via period doubling, period halving as well as the secondary Hopf bifurcations are predicted. The secondary Hopf bifurcation leads to the occurrence of the quasi-periodic orbits. They are also traced numerically with a very high accuracy. Introducing a general Poincare map a problem of tracking a quasiperiodic solution is reduced to an investigation of the fixed point of the general Poincare map. Both autonomous and nonautonomous discrete dynamical systems are considered. In the first case a m-dimensional torus possesses m independent basic irrational frequencies, which are a priori known. The known irrational numbers are approximated using fractional expansion. This approximation allows us to find the surface of torus. In the latter case first the method of finding unknown frequencies is proposed and a similar Poincare map is defined to find a fixed point representing a torus. The consideration of stability and bifurcation of quasiperiodic orbits is reduced to investigation of stability and bifurcation of the fixed point.

In both cases the transition to chaotic orbit via period doubling and saddle-node bifurcation is illustrated and discussed. Chaotic attractors are characterized using methods based on solving an initial value problem, such as the Lapunov exponent, frequency spectra, phase portraits and so on.

The presented techniques are applied to the investigation of the vocal cord oscillations, as well as a few mechanical systems consisting of coupled oscillators.