UDC681.5.0123

SYNTHESIS OF A MODAL MOTION CONTROL ELEMENTS OF A REVERSE PENDULUM WITH GENETIC ALGORITHM

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This study aims to analyze the mathematical model and properties of the reverse pendulum, synthesis of a modal motion control system: state-space regulator and Luenberg observer. As well as the optimization of the desired spectrum of the “Segway” model based on the genetic algorithms.

Introduction. Today one of the most important objectives of the Control theory is solving the stability problem of the physical system and its ability to return to a balanced state. But despite this being the most logical solution there are a lot of applications for unstable systems. The prime example of this is the reverse pendulum system. Initially this model was described in the study [1]. Now you can come across it in almost any industry from robotics to space tech. There are a wide variety of methods and instruments that can be applied for this task. Such as pendulum control with a feedback using hysteresis inverter described in the study [2], continuous root placing of the characteristic polynomial of the closed-loop system presented in the study [3] and a quantity of others.

Based on the data we collected there are also modal control methods involved in reverse pendulum handling problems. Some of them are actually using neural networks like in the study [4]. But the process of the spectral matrix eigenvalues optimization still remains open.

Main part.

Research problem: Lack of optimization algorithm for finding desired system matrices spectrum in modal control of the reverse pendulum.

Research hypothesis: Application of a genetic algorithm for finding system matrices eigenvalues can provide the most optimal synthesis of the modal elements of this system.

Aim of Research: Development of a genetic algorithm for finding desired spectrum system matrices that will optimize modal synthesis process, as well as provide easier selection of eigenvalues.

Research task: Derivation of the mathematical model of a study object, synthesis of a modal state regulator, synthesis of a Luenberger observer, closed-loop system analysis, genetic algorithm implementation.

After the Segway mathematical model derivation, construction of the robot and measurements of its physical parameters are done we can fully describe it in state-space form. Subsequent to the controllability and observability analysis we can move to the modal synthesis and get a static state regulator and Luenberg observer. The genetic algorithm will be used for solving the optimization problem.

Genetic algorithm is an evolutionary approach for finding optimal solutions to almost any task. It mimics a real natural selection process with a crossover, mutation and selection. Those steps can be repeated as many times as it takes to attain the desired results.

One Gurwitz matrix that contains the desired spectrum is called an individual. A group of individuals creates a generation. Just like in the real world this algorithm implements natural selection – the process of selecting best individuals corresponding to our metrics and assuring stable performance of our mathematical model with these individuals as aim spectrum in the stability problem.

We have decided to take a two argument function that depends on the maximum deviation of a step response from a setted value and transient time. Those parameters were chosen to be a part of the evaluation process since they are also used for selecting eigenvalues with standart Newton-Butterfort polynomials [5]. The final values of an evaluation function are normed. By that way we can assign any individual a real number from 0 to 1.

For the mathematical model realization, behavioral modeling and implementation of the genetic algorithm we chose the MATLab/Simulink platform. Today these tools are one of the most popular in the field of dynamic processes imitation modeling. They have embedded libraries and packages that can solve a wide variety of tasks from conceptual constructing to code generation and hardware implementation.

Conclusion. Indicators of the effectiveness of the developed algorithm will be: optimization of finding the eigenvalues of the system matrices for the modal controller and the Luenberger observer, as well as the quality of transient processes (overshoot and transient process time) for the balancing one-wheeled Segway robot.

Today, based on the MATLab/Simulink software environment, we have developed a genetic algorithm and the architecture of a linearized model of a balancing robot - an inverse pendulum, and also synthesized modal elements for controlling its movement with the most optimal matrices of the desired spectrum. In the future, it is planned to improve the algorithm using computer simulation and adjust its performance.

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