Controller Design Based on Genetic Programming

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ABSTRACT
Three genetic programming-based approaches are proposed for continuous-time process control design. Two approaches are represented using a network of interconnected continuous-time or discrete-time elementary dynamic building blocs. In the third approach the control algorithm is represented as a recurrent function of discrete-time input variables.

Categories and Subject Descriptors
C.3 SPECIAL-PURPOSE AND APPLICATION-BASED SYSTEMS - *Process control systems*

General Terms
Algorithms, Design, Theory

Keywords
Genetic programming, continuous-time process, controller architecture design, elementary function blocs, recurrent function.

1. INTRODUCTION
In continuous-time process control we have to design controllers for different types of systems with complex structure and specific dynamics. For that reason it is necessary to use various control algorithms. Modern control theories are able to solve complex tasks, however sometimes the applied approaches are solving just particular problems. This appears often in cases when the system to be controlled has nontrivial structure, complex static or dynamic behavior, nonlinearities, several inputs/outputs and it is affected by noise or disturbances. The design process may be complicated, discontinuous or non-convex, and analytical methods often may not be able to yield satisfactory results. Opposite to this, evolution-based search/optimization approaches are able to construct new control laws and non-intuitive solutions as well.

2. CONTROLLER EVOLUTION
The controller design principle is actually an optimization task – search for such a controller structure and its parameters, which minimize the chosen performance index. The evaluation of the fitness consists of three steps [1]. The first step is the transformation from the individual representation of the controller in the GP domain (tree, matrix, etc.) into the simulation model. The second step is the computer simulation of the closed-loop time response and the last one is the performance index evaluation e.g. (1) or other.

$$I = \int_0^T |e(t)| dt + \alpha \int_0^T |\dot{y}| dt \tag{1}$$

T is the simulation time, e is the control error and $\dot{y}$ is the controlled variable derivative.

We have proposed three various approaches. In the first one the control algorithm representation is based on an interconnected network, which consists of the following elementary continuous-time dynamic function blocks: integrator, derivative unit, gain, and summation. The objective is to find the optimal control network consisting of such elementary function blocks and their interconnections, that minimizes the performance index. In the second proposed approach a discrete-time recurrent control algorithm has been designed as function of defined time-delayed input variables in the form

$$F(\theta)=? \qquad \theta =\{e(k), e(k-1), ..., e(k-m), y(k), y(k-1), ..., y(k-n), u(k-1), u(k-2), ..., u(k-p), r(k), c\} \tag{2}$$

where e is the control error, y is the controlled output, u is the control value and k is the discrete time-step. The last representation of the designed controller is a combination of the previous two. The discrete-time controller is represented by a tree topology, which items are elementary discrete-time function blocks: summation, product, gain and time-delay.

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3. REFERENCES
[1] Sekaj, I. Šrámek, M. *Robust Controller Design Based on Genetic Algorithms and System Simulation*. In Proceedings on the conference CDC-ECC'05, December 12 – 15, Seville, Spain, 2005

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