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ARTIFICIAL NEURAL NETWORK AS A UNIVERSAL APPROXIMATOR

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One of the possible ways of approximation of some data sets is connected with the use of a learned artificial neural network (ANN). There is the universal approximation theorem [1], which states that a feed-forward ANN with a single hidden layer containing a finite number of neurons (nodes) can approximate continuous functions on compact subsets, under mild assumptions on the activation function. One of the first versions of the theorem was proved by George Cybenko [2] (as an activation function he applied sigmoid).

For instance, let consider a problem of automatic control: there is an unstable plant, which is described with the following transient function $G = \frac{1}{s^2 - 1}$ (it may be a one of representation of the mathematical model of an inverted pendulum); the cost function of the control is RMS of control (the control is the output of the considered ANN). The structure of the ANN concludes four layers of five nodes (neurons). The activation function of the nodes is sigmoid with a bias. The problem states that biases and weights should be found: their numerical values minimize the cost function.

In order to solve the stated problem, the ME-D-PSO method was applied. The results might be shown in a form of the 3D plot (fig. 1): as ANN has two inputs (controlled coordinate *x* and its first derivative with respect to time) and one output (control function) it is convenient to present such a plot.

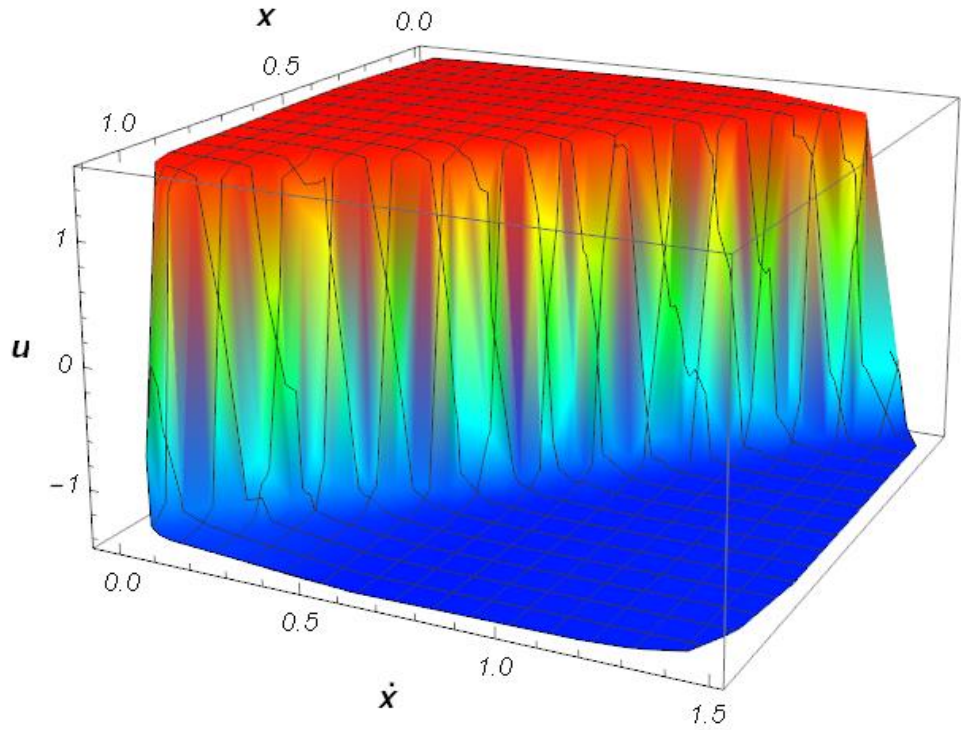

Fig. 1. 3D-plot of the function of the learned ANN-controller

Plot on the fig. 1 clearly shows, that learned ANN-controller acts like an MISO function. It transforms the input vector into output control (scalar). Moreover, it is limited: lower and upper bounds do not violate values -1,5 and 1,5 respectively. Generally, ANN serves as the universal approximator of the optimal controller. Thus, the exploitation of ANN in the different systems of optimal control leads to quite good results. They are based on strong approximation features of ANN.

References

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