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SUMMARY

Thesis title: „Application of recurrent neural networks in a control of drive system with a complex mechanical part"

The doctoral thesis is focused on the speed control of a drive with a compound mechanical part. For this purpose recurrent neural networks have been applied. The electrical drive consists of two motors coupled with a long shaft – the construction is named two-mass system. Elasticity of the connection is not negligible, because it can cause torsional vibrations. In case of classical structures (with PI controllers) application, oscillations of state variables can be noticed in the system. Considering the above described conditions of the drive operations, long term use can lead to damaging the system and precise control is difficult. The aforementioned phenomena can be widely observed in rolling-mill drives, conveyor belts, or deep-space antennae. The application of recurrent neural networks can ensure a high dynamic response of the drive and adaptation to the current state of the drive.

Within the scope of the dissertation, a literature review, related to the application of recurrent neural networks in electrical drives, was conducted. According to the current state of knowledge, recurrent models offer increased robustness and higher dynamics of signal shaping, compared to classic – feedforward – structures. It was the main reason of application as speed controllers of the drive with elastic joint. Moreover, metaheuristic algorithms were used to establish quasi-optimal coefficients of adaptive recurrent controllers. The calculations have been done for parameters important considering dynamics and the design process: learning rate (η) and the external gains (k_e, k_{de} and k_i). The thesis is focused on three types of neural networks: Elman, recurrent wavelet network (***Recurrent** Wavelet **Neural** Network*) and the LSTM model (***Long** Short-**Term** Memory*). As optimizers three different metaheuristic algorithms were applied: (*Artificial **Bee** Colony*), GWO (*Grey **Wolf** Optimizer*) and SOS (*Symbiotic **Organisms** Search*). Moreover, the modification of the GWO algorithm was proposed.

The research was conducted for six different reference trajectories of speed and load torque. Reference speed was set as 25% of a nominal value, the sinusoidal and square waveforms were used. Based on the performed tests, the best results (according to the performance

index *J*) were achieved using a control structure with a speed controller based on an RWLNN. On the other hand, the ABC optimizer provided the best solutions in comparison to the other implemented methods. The analyzed control structures perform on-line recalculation of internal parameters. As a result, the models can be adjusted to changes of the object (e.g. fluctuation of the time constants).

In the final stage of the thesis, after literature analysis, theoretical considerations, and simulations, results were verified in the experiment. The first used laboratory configurations, relies on the dSPACE prototyping card, the second is based on a low-cost Discovery board (based on an ARM chip). Two motors (with nominal power – 500W) were used in both cases. The parametric disturbance, and changes of the time constants of the shaft and the load machine can be defined by the user. The achieved results are consistent with the simulations and confirm the main doctoral dissertation thesis.

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PhD student signature