MSC: 68T27 Original article

Building a PID controller using neural networks

R.A. Zhilov

Institute of Applied Mathematics and Automation –

branch of Kabardino-Balkarian Scientific Center of the Russian Academy of Sciences

360000, Russia, Nalchik, 89 A Shortanov street

Abstract. The paper considers the use of neural networks to tune the PID controller. The need to use machine learning methods for tuning regulators stems from the complexity and duration of such tuning by a human. For each control object, a specialist has to adjust the PID controller coefficients, and in dynamic systems, they also have to be reconfigured. Also, the work assumes the use of hybrid neurocontrol systems and hybrid neural networks to simulate the operation of the PID controller itself. Recurrent neural networks are a powerful class of models that are well suited for modeling non-linear systems. One of the main applications of such neural networks is the control system. A sufficiently well trained recurrent neural network can simulate the operation of a PID controller. The advantage of this kind of controller is more accurate learning in conditions of only a fairly complete training set and the need for further adjustment by an expert. Also, replacing the PID controller system and the neuromodule with a hybrid neural network that performs the full work of this system simplifies it.

Key words: hybrid neural networks, PID controller, neurocontrol, recurrent neural networks

REFERENCES

1. Osovsky S. *Neyronnyye seti dlya obrabotki informatsii* [Neural networks for information processing]. Moscow: Finansy i statistika, 2016. (In Russian)

2. Omatu S., Khalid M., Yusof R. *Neyroupravleniye i yego prilozheniya. Neyrokomp'yutery i ikh primeneniye* [Neurofeedback and its applications. Neurocomputers and their applications]. Moscow: Radiotekhnika, 2017. (In Russian)

3. Zhuchkov A.A. The use of neural networks for the implementation of typical tasks of process control systems for nuclear reactors with the involvement of risk reduction criteria. *Trudy VIII vserossiyskoy konferentsii "Neyrokomp'yutery i ikh primeneniye" s mezhdunarodnym uchastiyem NKP-2002* [Proceedings of the VIII All-Russian Conference "Neurocomputers and their application" with international participation NKP-2002]. Moscow. 2012. Pp. 592–593. (In Russian)

4. Eliseev V.L. Methodology for constructing a training sample for neural network identification under conditions of stochastic signals. *Trudy XXXVII mezhdunarodnoy*

konferentsii "Informatsionnyye tekhnologii v nauke, obrazovanii, telekommunikatsii i biznese" [Proceedings of the XXXVII International Conference "Information Technologies in Science, Education, Telecommunications and Business"]. Alushta. 2010. (In Russian)

5. Eliseev V.L. Neural network analogue of PID controller for controlling a non-linear object. *Trudy XVI vserossiyskoy nauchno-tekhnicheskoy konferentsii studentov, molodykh uchenykh i spetsialistov "Novyye informatsionnyye tekhnologii v nauchnykh issledovaniyakh"* [Proceedings of the XVI All-Russian Scientific and Technical Conference of Students, Young Scientists and Specialists "New Information Technologies in Scientific Research"]. Ryazan. 2011. Pp. 199–201. (In Russian)

6. Eliseev V.L., Zenkevich S.L. Method of neural network optimal control. *Trudy Devyatoy vserossiyskoy nauchno-prakticheskoy konferentsii "Aktual'nyye problemy zashchity i bezopasnosti"* [Proceedings of the Ninth All-Russian Scientific and Practical Conference "Actual Problems of Protection and Security"]. Vol. 5. St. Petersburg. 2016. Pp. 251–256. (In Russian)

7. Eliseev V.L., Filaretov G.F. *Modelirovaniye PID-kontrollera s pomoshch'yu iskusstvennoy neyronnoy seti* [Modeling a PID controller using an artificial neural network]. Perspektivnye tekhnologii avtomatizatsii. Vologda. 1999. P. 108. (In Russian)

8. Eliseev V.L., Filaretov G.F. Features of tuning a neural network controller in the control loop. *Trudy XV mezhdunarodnogo nauchno-tekhnicheskogo seminara "Sovremennyye tekhnologii v zadachakh upravleniya, avtomatiki i obrabotki informatsii"* [Proceedings of the XV International Scientific and Technical Seminar "Modern Technologies in Control, Automation and Information Processing Problems"]. Alushta: 2016. P. 155. (In Russian)

9. Eliseev V.L., Filaretov G.F. Method of synthesis of a neural network control system for a non-stationary object. Vestnik MEI /MPEI Bulletin. 2010. No. 3. Pp. 100–106. (In Russian)

10. Eliseev V.L., Filaretov G.F. Software package for modeling and teaching methods of neural network control. *Otkrytoye obrazovaniye* [Open Education]. 2011. No. 2(86). Part 2. Pp. 98–101. (In Russian)

11. Ostrem K.Yu. *Vvedeniye v stokhasticheskuyu teoriyu upravleniya* [Introduction to Stochastic Control Theory]. Moscow: Mir, 1973. (In Russian)

12. Eremin D.M. *Razrabotka i issledovaniye neyrosetevogo regulyatora dlya sistem avtomatizirovannogo upravleniya* [Development and research of a neural network controller for automated control systems]: Ph.D. Dissertation Summary. 1995. 23 p. (In Russian)

13. M. Al-Amin, M.S. Islam Design of an Intelligent Temperature Controller of Furnace System using the Fuzzy Self-tuning PID Controller. *International Conference on Electronics, Communications and Information Technology (ICECIT),* 2021. Pp. 1–4. DOI: 10.1109/ ICECIT54077.2021.9641467.

14. Mahmud M., Motakabber S.-M.A., Zahirul Alam H.M., Nordin A.N. Adaptive PID Controller Using for Speed Control of the BLDC Motor. *IEEE International Conference on Semiconductor Electronics (ICSE)*, 2020. Pp. 168–171. DOI: 10.1109/ ICSE49846.2020.9166883.

15. Wang T., Chang C. Hybrid Fuzzy PID Controller Design for a Mobile Robot. *IEEE International Conference on Applied System Invention (ICASI),* 2018. Pp. 650–653. DOI: 10.1109/ICASI.2018.8394340.

16. Mohamad Ali Tousi S., Mostafanasab A., Teshnehlab M. Design of Self Tuning PID Controller Based on Competitional PSO. *4th Conference on Swarm Intelligence and Evolutionary Computation (CSIEC),* 2020. Pp. 22–26. DOI: 10.1109/CSIEC49655.2020.9237318.

17. Merayo N. [et al.] PID controller based on a self-adaptive neural network to ensure qos bandwidth requirements in passive optical networks. *Journal of Optical Communications and Networking*. Vol. 9. No. 5. Pp. 433–445. May 2017. DOI: 10.1364/JOCN.9.000433.

18. Belov M.P., Truong D.D., P. van Tuan Self-Tuning PID Controller Using a Neural Network for Nonlinear Exoskeleton System. *II International Conference on Neural Networks and Neurotechnologies (NeuroNT),* 2021. Pp. 6–9. DOI: 10.1109/NeuroNT 53022.2021.9472852.

19. Wang R., Zhou Z., Qu G. Fuzzy Neural Network PID Control Based on RBF Neural Network for Variable Configuration Spacecraft. *2018 IEEE 3rd Advanced Information Technology, Electronic and Automation Control Conference (IAEAC),* 2018. Pp. 1203–1207. DOI: 10.1109/IAEAC.2018.8577860.

20. Ahmed A.A., Saleh Alshandoli A.F. On replacing a PID controller with Neural Network controller for Segway. *2020 International Conference on Electrical Engineering (ICEE),* 2020. Pp. 1–4. DOI: 10.1109/ICEE49691.2020.9249811.

Information about the author

Zhilov Ruslan Alberdovich, Junior researcher, Neuroinformatics and Machine Learning Department, Institute of Applied Mathematics and Automation – branch of Kabardino-Balkarian Scientific Center of the Russian Academy of Sciences;

360000, Russia, Nalchik, 89 A Shortanov street;

zhilov91@gmail.com, ORCID: https://orcid.org/0000-0002-3552-4854