Development of a route setting model in the dispatching centralization system

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Abstract. These days, automation and remote control technologies provide the foundation for the organization of train movement across several categories. At railroad sections and stations, dispatcher centralization systems are utilized to guarantee the security of train movement. However, in the railroad portions where high-speed train movements are organized, time limitations based on the human factor are being implemented. Consequently, this results in longer wait times for technological processes at stations and longer train intervals on some railway segments. Developing an automated route preparation procedure at stations in dispatching centralization systems will allow for the resolution of current issues. A dispatching centralized system model for route establishment has been created in this scientific study. Using a two-layer neural network, a mathematical model of route setting in the dispatcher centralization system was determined. Neural networks are employed in rail dispatch rooms for intelligent route comparison and in dispatcher centralized systems for tracking train routes at stations.

1 Introduction

Safe passenger and freight delivery to destinations is the primary function of railway transportation. Automated systems and remote control devices guarantee traffic safety in railway transportation. In scenarios with very poor reliability, these systems are prone to errors when providing train traffic. Serious accidents and significant financial losses can result from even minor errors [1–14]. In order to guarantee the safety of train movement, automation and remote control systems should have their level of safety inspected.

2 Materials

The safe conveyance of people and products to their destination is the primary responsibility of railroad transportation. Automation and remote control systems and equipment provide traffic safety in railway transportation. When supplying rail traffic in scenarios with very poor reliability, these systems are prone to errors. Small errors might

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result in significant financial losses and occasionally even deadly mishaps [14–21]. Thus, the safety degree of automation and remote control systems that guarantee the security of train movement should be examined.

Many efforts are being made today to expand the transportation industry and quicken rail speeds. This necessitates creating new specifications for automation and remote control systems in order to plan the passage of fast-moving trains.

The following are the primary objectives of "Uzbekistan Railways" JSC's high-speed train transportation planning:

- creation of an efficient and modern transportation infrastructure, a boost to the economy's flow of commodities, and a decrease in transportation expenses;
- expand the population's opportunities to utilize the transportation complex's services;
- enhancing the transport system's overall stability and safety;
- enhancing the climate for transportation investments and growing market connections;
- in order to accomplish these objectives, the following tasks must be completed;
- creation of channels of communication;
- railway line upgrade to facilitate high-speed passenger transportation;
- creation of a single road network to facilitate population transportation throughout the year;
- making international transportation networks more competitive;
- guaranteeing the safety of transportation;
- creation of an all-encompassing traffic congestion management system;
- creation and improvement of mechanisms for managing investment projects.

Increasing the carrying capacity of certain railway network segments, updating the permanent devices and structures of railway transport, and electrifying railway lines are just a few of the challenges that must be resolved in order to establish a modern and effective transportation infrastructure [17].

In order to enhance train traffic management, automating the route-setting process in the dispatching centralized system of railway sections is regarded as one of the most pressing concerns of the day.

3 Methods

We put into practice the procedure of using a multilayer neural network to describe how the dispatching centralized system of train traffic control operates on railway sections.

A neural network with input, output, and one or more hidden layers of neurons makes up a multilayer neural network. These neural networks have intermediate, hidden layers in addition to input and output layers. Although techniques for training hidden-layer neurons are relatively new, such networks offer far more potential than single-layer neural networks.

One way to think about the function of buried layers of neurons is like a vast factory. The output signal, or product, is constructed on the machines in the factory one step at a time. A semi-final result is obtained for every machine. Additionally, input signals are converted into certain intermediate outputs by hidden layers.

The route setting based on the artificial neural network model [19–35] is shown in Figure 1, accounting for the train's moving stations. We will construct the neuron set in two layers in this instance[34-35]. Table 1 contains a list of its layers.

In this instance, dispatching centralization system route-setting equations are derived.

The input layer presents data in the form of X1 regarding the current state of the traffic structure. This layer stores the data that is received from the train and sends it to the

system's central processor.

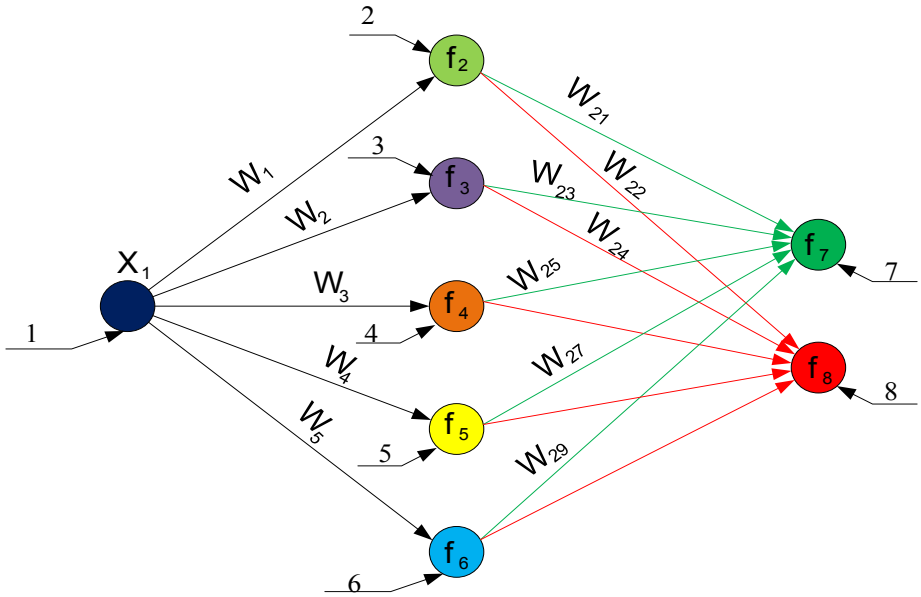

Fig 1. Routing in dispatch center systems by artificial neural network modeling.

The first hidden layer displays the following information: the train's disbandment, the option to accept the train from the next station, the automation and remote control of the receiving station, the condition of communication devices, the receiving station's roads, and the traffic structure's priority. Processed data from the traffic structure is present in this layer.

$$f_2 = x_1 w_1,\ y_2\left(f_2\right) = y_2\left(x_1 w_1\right) \quad (1)$$

$$f_3 = x_2 w_2,\ y_3\left(f_4\right) = y_3\left(x_2 w_2\right) \quad (2)$$

Table 1. Neural chain propagation in a dispatching centralization system's routing configuration.

Layers	No	Tasks	Content
Enter	1.		Parameters of the movement composition
Hidden layers	2.		Priority of movement
	3.		Status of automation and remote control devices on the route
	4.		Possibility of reception station
	5.		Development of station roads on the route
	6.		Formation / Disbandment of trains
Exit	7.		Sending a TC command
	8.		Prohibition of TC command

To create a route from the CPU, create a transmit or block TC command at the output layer.

$$f_7 = y_2 w_{21} + y_3 w_{23} + y_4 w_{25} + y_5 w_{27} + y_6 w_{29}$$
$$y_7\left(f_7\right) = y_7\left(y_2 w_{21} + y_3 w_{23} + y_4 w_{25} + y_5 w_{27} + y_6 w_{29}\right) \quad (3)$$

The sequence given in scientific works can be used to establish the priority of the movement composition [6–8]. The TS signal indicates the automation and remote control device status along the route.

The data transmission networks (DTN) distributed automated control systems (ACS) [14–23] is the source of information regarding the establishment or dissolution of the movement structure.

4 Conclusion

These days, automation and remote control technologies provide the foundation for the organization of train movement across multiple categories. At railroad segments and stations, dispatcher centralization systems are utilized to guarantee the security of train movement. However, in the railway portions where high-speed train movements are organized, time constraints based on the human factor are being adopted. Consequently, this results in longer wait times for technological processes at stations and longer train intervals on certain portions of the railway. By creating an automated process for route preparation at stations in dispatching centralization systems, the current issues can be resolved. Upon establishing the routes in the dispatching centralized system, the TC command is generated in the automated workstation for train dispatcher (AW TD) and transmitted to the line point following the determination of the traffic composition parameters, receiving station paths, automation status, and remote control device status. In this research work, a two-layer neural set was used to construct a model for dispatch center system route setting. As a result, routes can be established using the intelligent mode and the data found in the AW TD. Additionally, AW TD's workload can be decreased.

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References

1. Nikitin, A., Manakov, A., Kushpil, I., Kostrominov, A., Osminin, A. (2020). *On the issue of using digital radio communications of the DMR standard to control the train traffic on Russian railways.* In 2020 IEEE East-West Design and Test Symposium, EWDTS 2020 - Proceedings. Institute of Electrical and Electronics Engineers Inc. https://doi.org/10.1109/EWDTS50664.2020.9224707.
2. Oparina, E. (2023). Lecture Notes in Networks and Systems **509**, 1035–1044). https://doi.org/10.1007/978-3-031-11058-0_105.
3. Popov, A. N., Bushuev, S. V., Galinurov, R. Z., Nikitin, A. B. (2021). AIP Conference Proceedings **2389** https://doi.org/10.1063/5.0063855.
4. Nikitin, D., Nikitin, A., Manakov, A., Popov, P., Kotenko, A. (2017). *Automatic locomotive signalization system modification with weight-based sum codes.*

In Proceedings of 2017 IEEE East-West Design and Test Symposium, EWDTS 2017. Institute of Electrical and Electronics Engineers Inc. https://doi.org/10.1109/EWDTS.2017.8110099.

5. Scholten, H., Westenberg, R., Schoemaker, M. (2009). Sensing train integrity. In Proceedings of IEEE Sensors (pp. 669–674). https://doi.org/10.1109/ICSENS.2009.5398340.
6. Wang, J., et.al., (2015). Journal of the China Railway Society, **37(12),** 46–52. https://doi.org/10.3969/j.issn.1001-8360.2015.12.008.
7. Hiraguri, S., Fukuda, M., Fujita, H., Ono, Y. (2012). Quarterly Report of RTRI (Railway Technical Research Institute) (Japan), **53(1),** 1–6. https://doi.org/10.2219/rtriqr.53.1.
8. Hiraguri, S. (2016). Recent research and development of signaling and telecommunications technologies. Quarterly Report of RTRI (Railway Technical Research Institute). Ken-yusha Inc. https://doi.org/10.2219/rtriqr.57.4_252.
9. Hiraguri, S. (2015, August 1). Recent research and development of signaling and telecommunications technologies. Quarterly Report of RTRI (Railway Technical Research Institute). Ken-yusha Inc. https://doi.org/10.2219/rtriqr.56.160.
10. Fujita, H., Arai, H., Sato, K. (2010). Quarterly Report of RTRI (Railway Technical Research Institute) (Japan), **51(4),** 189–195. https://doi.org/10.2219/rtriqr.51.189.
11. Kawasaki, K. (2021). Outlines and future outlook of research and development activities relating to utilization of information and communication technology for signalling and telecommunication systems. Quarterly Report of RTRI (Railway Technical Research Institute). Ken-yusha Inc. https://doi.org/10.2219/rtriqr.62.2_83.
12. Kawasaki, K. (2020). Trends and topics of research and development related to the sophistication of signalling and telecommunication systems. Quarterly Report of RTRI (Railway Technical Research Institute). Ken-yusha Inc. https://doi.org/10.2219/RTRIQR.61.2_82.
13. Kawasaki, K., Seki, K. (2015). Quarterly Report of RTRI (Railway Technical Research Institute), **56(1),** 33–38. https://doi.org/10.2219/rtriqr.56.33.
14. Kitano, T., Sasaki, T., Sugiyama, Y. (2015). Quarterly Report of RTRI (Railway Technical Research Institute), **56(1),** 45–50. https://doi.org/10.2219/rtriqr.56.45.
15. Baratov D., Astanaliev E. //E3S Web of Conferences. 2023. **402**. 03018. https://doi.org/10.1051/e3sconf/202340203018.
16. Hiraguri, S. (2017, November 1). Recent research on application of ICT for railway. Quarterly Report of RTRI (Railway Technical Research Institute). Ken-yusha Inc. https://doi.org/10.2219/rtriqr.58.4_254
17. Zhang, Y., Ma, M., Wang, J. (2021). Journal of the China Railway Society, **43(7),** 77–86. https://doi.org/10.3969/j.issn.1001-8360.2021.07.010
18. Takashige, T. (2002). Overview of recent signalling and telecommunications technologies. Quarterly Report of RTRI (Railway Technical Research Institute) (Japan). Ken-yusha Inc. https://doi.org/10.2219/rtriqr.43.153.
19. Baratov D., Astanaliev E. //E3S Web of Conferences. 2023. **402**. 06005. https://doi.org/10.1051/e3sconf/202340206005.
20. J. F. Kurbanov and A. A. Saitov, "*Microprocessor System Control Stage of Railway Tracks,"* 2023 International Conference on Industrial Engineering, Applications and Manufacturing (ICIEAM), Sochi, Russian Federation, 2023, pp. 755-761, https://doi.org/10.1109/ICIEAM57311.2023.10139088.

21. Kurbanov, J.F., Toshboyev, Z.B.U. (2023). *Improving the Control Method of the Decelerator Mechanism on the Sorting Hill in Railway Transport.* In Proceedings - 2023 International Conference on Industrial Engineering, Applications and Manufacturing, ICIEAM 2023 (pp. 762–768). Institute of Electrical and Electronics Engineers Inc. https://doi.org/10.1109/ICIEAM57311.2023.10139276.
22. S Boltayev., Q Kosimova., E Astanaliev., I Kodirov. E3S Web of Conferences. BFT-2023. **460**. 06004. https://doi.org/10.1051/e3sconf/202346006004.
23. Saitov, A., Kurbanov, J., Toshboyev, Z., Boltayev, S. (2021). E3S Web of Conferences **264**. https://doi.org/10.1051/e3sconf/202126405031.
24. Azizov, A., Ametova, E., Nuriddinov, Q., Ubaydullayev, S. (2023). E3S Web of Conferences **371**. https://doi.org/10.1051/e3sconf/202337103069.
25. Qobulov, J., Barotov, J. *Effective organization of technologies for speeding up freight transportation in railway transport* // E3S Web of Conferences. Ural Environmental Science Forum on Sustainable Development of Industrial Region, UESF 2023. https://doi.org/10.1051/e3sconf/202338905042.
26. Qobulov, J., Barotov, J., Shermatov, E., Fayzullaev, G. *Improvement of service technology on railway branch roads* // E3S Web of Conferences. International Scientific Siberian Transport Forum, TransSiberia 2023. https://doi.org/10.1051/e3sconf/202340206008.
27. Muhiddinov, O., Boltayev, S. (2023). E3S Web of Conferences **376**. https://doi.org/10.1051/e3sconf/202337604033.
28. Boltayev, ST, Kosimova, QA (2022). Proceedings - International Ural Conference on Measurements, UralCon **2022**, pp. 290–294). https://doi.org/10.1109/UralCon54942.2022.9906687.
29. Boltayev, ST, Valiyev, SI, Kasimova, QA (2022). *Improving the Method of Sending Information about the Approach of Trains to Railway Crossings.* In Proceedings of the 2022 Conference of Russian Young Researchers in Electrical and Electronic Engineering, ElConRus 2022 (pp. 558–565). https://doi.org/10.1109/ElConRus54750.2022.9755564.
30. Boltayev, ST, Abdullaev, RB, Ergashov, BG, Hasanov, BQ (2022). *Simulation of a Safe Train Traffic Management System at the Stations.* In Proceedings of the 2022 Conference of Russian Young Researchers in Electrical and Electronic Engineering, ElConRus 2022 (pp. 566–571). https://doi.org/10.1109/ElConRus54750.2022.9755616.
31. Boltayev, S., Rakhmonov, B., Muhiddinov, O., Saitov, A., Toshboyev, Z. (2021) E3S Web of Conferences **264**. EDP Sciences. https://doi.org/10.1051/e3sconf/202126405043.
32. Baratov, D., Aripov, N., Mukhiddinov, O., Jumanov, K. (2022). AIP Conference Proceedings **2432**. https://doi.org/10.1063/5.0089758.
33. Baratov, D., Aripov, N., Muhiddinov, O., Jumanov, X. (2022). *A Model of Electronic Document Management of Technical Documentation for Railway Automation.* In Lecture Notes in Mechanical Engineering (pp. 481–492). https://doi.org/10.1007/978-3-030-85057-9_40.
34. S. Haykin. Neural Networks and Learning Machines. 3rd Edition. Pearson, 2018.
35. CC Aggarwal. Neural Networks and Deep Learning. A Textbook. Springer International Publishing AG, 2018. https://doi.org/10.1007/978-3-319-94463-0 ISBN 978-3-319-94462-3.