ORIGINAL SCIENTIFIC PAPER SIGURNOST 62 (3) 259 - 264 (2020)

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MODELLING OF FUZZY LOGIC BASED DISPATCHER SUPPORT SYSTEM FOR RAILWAY TRAFFIC CONTROL IN STATION AREA

UDK 656.2.089:004
RECEIVED: 2019-01-08
ACCEPTED: 2020-02-10

SUMMARY: Modern approach to rail traffic control on major corridors implies centralized train and traffic control. In such approach, the main role in traffic management has railway dispatcher. With the aim of reducing the dispatcher's workload while simultaneously raising the performance level and increasing the efficiency of the dispatcher's work, with a goal of greater efficiency in the process of traffic control, adequate decision support systems are being developed. Within this paper, a model of the dispatcher support system in decision-making in the railway traffic control process based on the application of artificial intelligence is presented. The proposed model of fuzzy logic based dispatcher support system in decision-making should, to a certain extent, decrease the possible negative impact of different distractors and factors of unfavorable circumstances from the working and traffic environment on the performance of the dispatcher's work.

Key words: *railway traffic control, dispatcher decision support, fuzzy logic*

INTRODUCTION

In the situation when two trains are approaching the same railway station sometimes they are not able to enter the station at the same time but one of them gets the advantage of entering the station (train 1 in the picture), while the other one must begin to slow down after the distant signal and stop in front of the home signal. This is due to railway safety principles which prevents train collision in the station area by setting train routes for trains which must not cross or touch each other and with related overlaps *(Pachl, 2015)*. For instance (see figure 1), green line presents a train route for train 1 and yellow one its related overlap. In this case train 2 is not allowed to enter the station until train 1 come to the end of movement authority i.e. green line and stops there.

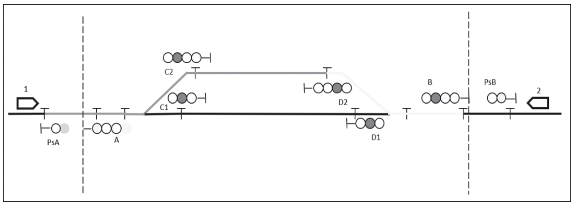

Figure 1. Trains approaching station conflict
Slika 1. Konflikt vlakova kod približavanja kolodvoru

Regarding to this, the second train will be allowed to enter the station after the first train successfully entered it and stop in front of the exit signal D2. The decision about which train has the advantage of entering the station is given by dispatcher. This decision-making process depends on dispatcher`s skills and experience and the quality of this process can be result of his cognitive workload and human factors. Because of this it is possible to develop a system that will assist the dispatcher in making such decisions *(Törnquist, 2005)*, or completely replace him. Additionally, this kind of system can be improved by communication links to train driver decision support

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systems located in trains via GSM-R with the purpose to improve user cost-based goals *(Pauer, Török, 2019)* such as better energy efficiency of train driving, less maintenance costs etc. In this paper a new model of fuzzy inference system for this purpose is presented. The development of this model is the result of the continuation of previous research related to the modelling of fuzzy logic based dispatcher support system for railway traffic control *(Haramina et al. 2018)*.

STRUCTURE OF THE DECISION SUPPORT SYSTEM

On the figure 2. structure and properties of fuzzy inference system for dispatcher decision support in traffic control process are presented.

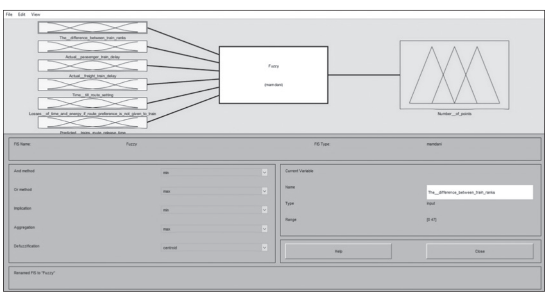

Figure 2. Structure of the decision support system
Slika 2. Struktura sustava za potporu odlučivanju

The system has six input variables and one output. Input variables are presented by factors influencing decision making process for train priority selection. As input variables the difference between train ranks, actual passenger train delay, actual freight train delay, time till route setting, losses of time and energy if route preference is not given to train and predicted route release time are selected.

The difference between train ranks

According to regulations in Croatia there are 21 ranks of trains *(Republic of Croatia, Ministry of the Sea, transport and Infrastructure)*. Because trains of the same rank from international traffic have an advantage over domestic trains, there are in total 24 different levels of train priority. Due to this and because the difference in rank may be in favor to one or another train in this input parameter for the comparison of trains considering the rank the range of 47 degree of difference between the priority level of trains is defined. This range is grouped into 7 fuzzy sets defined by membership functions (see figure 3).

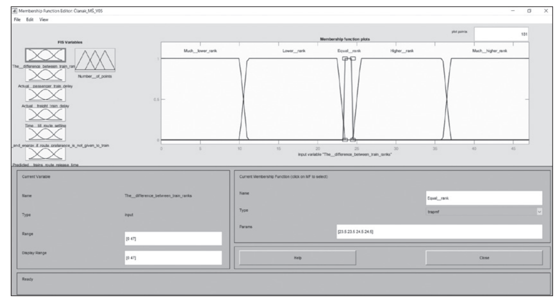

Figure 3. The difference between train ranks
Slika 3. Razlika u rangu vlakova

Train delay

The amount of train delay can affect the priority of that train. A train that already has a big delay should try as far as possible to reduce or at least not increase existing delay. That is in rail transport primarily referred to passenger trains, as well as higher-rank trains which, because of their rank can have higher negative impact on delays of other trains.

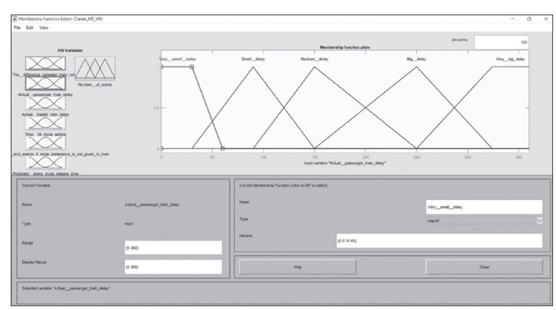

Figure 4. Actual passenger train delay
Slika 4. Stvarno kašnjenje putničkog vlaka

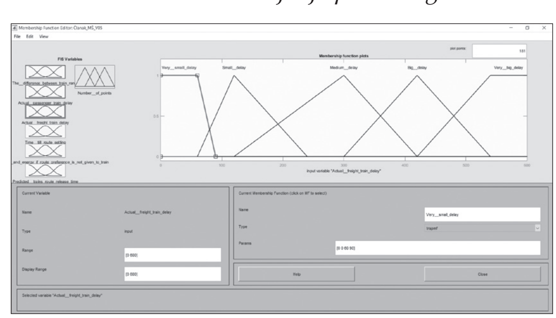

Figure 5. Actual freight train delay
Slika 5. Stvarno kašnjenje teretnog vlaka

Time till route setting

The priority given to a train which is at a greater distance from the starting point of its route occupation can affect the railway line capacity and the delay of the competitive train. On the figure 6 range and membership functions for input value time till route setting for station entrance are presented.

Figure 6. Time till route setting for station entrance

Slika 6. Vrijeme do postavljanja puta vožnje za ulaz u kolodvor

Losses of time and energy if route preference is not given to train

In case when we have massive freight train which is running at full speed, it is more worth it to give the priority to this train than much less massive higher rank train that would not be too late in that case, because the massive freight train would have significantly saved its time (avoiding delay) and energy *(Yinping et al. 2009)*. This is connected with the fact that long massive trains using indirect brakes cannot start their run again immediately after stopping, but after the pressure in braking pipes is achieved again.

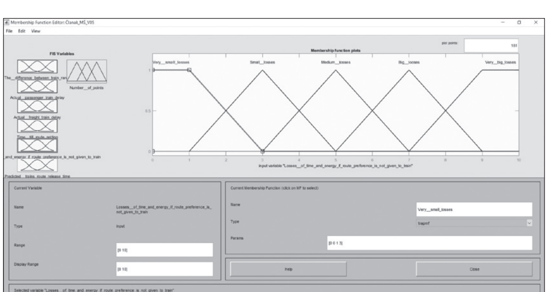

Figure 7. Losses of time and energy if route preference is not given to train

Slika 7. Gubitci vremena i energije u slučaju da vlak ne dobije prioritet kod postavljanja puta vožnje

Predicted route release time

Route release time for some train can be predicted by using data of route setting time, train running time from the train position when the route is set (in some ideal case it should be the sight distance of distant signal) till the end of movement authority (in this case it is in front of the exit signal) which is based on infrastructure data and train dynamics (e.g. for this purpose for calculation of train running time microsimulation models created in OpenTrack or RailSys can be used) and the time needed for interlocking to release train route and related overlap which depends on the type of station interlocking device and applied method of traffic management (e.g. with station dispatchers or with dispatcher for centralized train and traffic control).

Designing of output variable

The output variable is designed in way that some train can be compared with its competitive train and by this reach between 0 and 100 points. Train which reaches more points will get advantage over its competitive train. In the case when both trains score the same number of points, priority will be given to the train with higher rank.

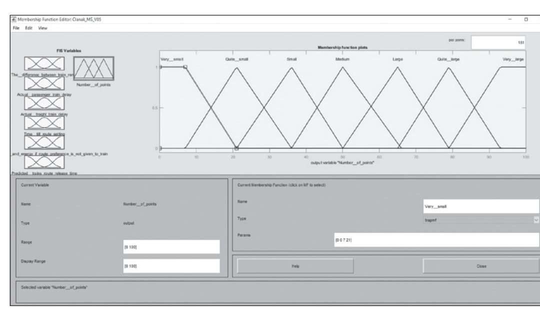

Figure 8. Designing of output variable

Slika 8. Definiranje izlazne varijable

KNOWLEDGE DATABASE OF THE SYSTEM

The inference process is conducted by rules stored in the knowledge database and real time data about the trains. The rules are created based on the experience in traffic control by relations between input and output variables. These relations are derived with logical operators in the Matlab graphical user interface.

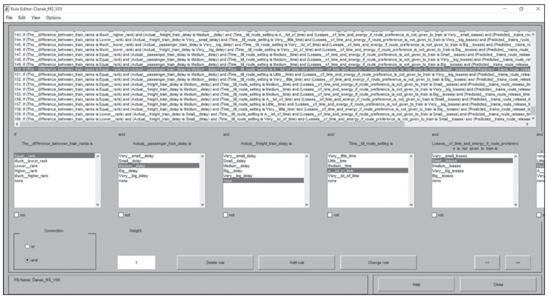

Figure 9. Definition of rules in knowledge database
Slika 9. Definiranje pravila u bazi znanja

Basic train data are collected from the timetable database, train delay data from the database of timetable realization monitoring system, while information about current train position and velocity can be collected in real time from the train control process by using the Train Describer System which collect data from track occupation detection system or by using of train control system with continuous traffic data transmission (e.g. ERTMS/ETCS level 2).

TESTING OF THE SYSTEM

The system was tested with scenario where two competitive trains were compared and the system has to choose which train should get priority to first enter the station area (see figure 1). The first train was long distance passenger train which had delay of 240 seconds, time till route setting of 60 seconds, losses of time and energy if route preference is not given to train 6 and predicted route release time 90 seconds. The second train was international freight train with delay of 120 seconds, time till route setting 140 seconds, losses of time and energy if route preference is not given to train 3 and predicted route release time 180 seconds. Result of the inference process showed that first train achieved 64,6 points and had priority over conflicted freight train which collected 28,9 points, as it is shown on the figure 10.

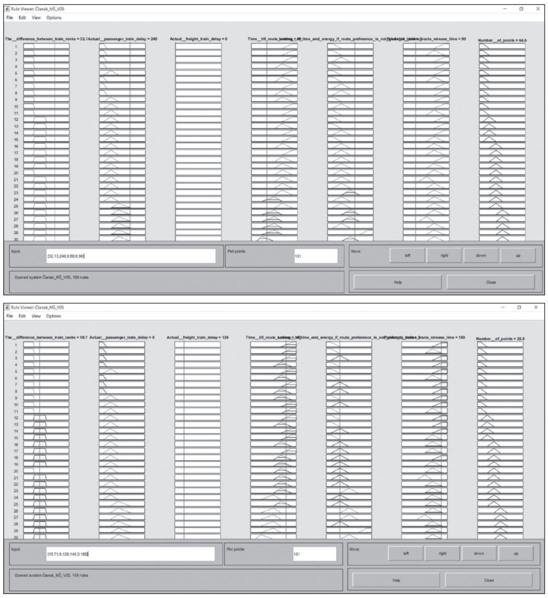

Figure 10. Testing of the system
Slika 10. Ispitivanje sustava

CONCLUSION

In this paper a new model of fuzzy inference system for train priority selection aimed for train dispatcher decision support was presented. The proposed model of inference system could be applied for each type of railway station and for each station individually. It would be installed on the computer unit in the station traffic office intended for operation of station dispatcher's decision support system.

This kind of system can reduce dispatcher's cognitive workload and improve his working performance. The input variables were selected and the rules in knowledge database were created based on experience in railway traffic control. The model is tested, and results proven the quality of system performance.

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MODELIRANJE DISPEČERSKOG SUSTAVA ZA PODRŠKU U UPRAVLJANU ŽELJEZNIČKIM PROMETOM U KOLODVORSKOM PODRUČJU TEMELJENOG NA NEIZRAZITOJ LOGICI (FUZZY LOGIC)

SAŽETAK: Suvremeni pristup upravljanju željezničkim prometom na glavnim koridorima podrazumijeva centralizirano upravljanje željezničkim prometom. U tom je pristupu glavna uloga u upravljanju prometom povjerena dispečeru. Imajući za cilj smanjenje radnog opterećenja dispečera i istovremeno povećanje razine performanse i efikasnosti njegova rada, te veću učinkovitost upravljanja prometom, razvijaju se prikladni sustavi potpore u odlučivanju. Članak prikazuje model sustava podrške u upravljanju željezničkim prometom temeljen na umjetnoj inteligenciji. Predloženi model sustava temeljenog na neizrazitoj logici trebao bi u određenoj mjeri smanjiti negativan učinak različitih distraktora i nepovoljnih okolnosti u radnom i prometnom okruženju na rad dispečera.

Ključne riječi: *upravljanje željezničkim prometom, podrška u odlučivanju dispečera, neizrazita logika*

Izvorni znanstveni rad
Primljeno: 8.1.2019.
Prihvaćeno: 10.2.2020.