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Traffic Engineering  
Original Scientific Paper  
Submitted: 31 Aug. 2020  
Accepted: 12 Jan. 2021  
DOI: 10.7307/ptt.v33i4.3686

# SCHEDULING OF TRAFFIC ENTITIES UNDER REDUCED TRAFFIC FLOW BY MEANS OF FUZZY LOGIC CONTROL

## ABSTRACT

*This paper presents the design of a fuzzy logic-based traffic scheduling algorithm aimed at reducing traffic congestion for the case of partial obstruction of a bi-directional traffic lane. Such a problem is typically encountered in rail traffic and personal rapid transportation systems with predefined and fixed traffic corridors. The proposed proportional-derivative (PD) fuzzy control algorithm, serving as a traffic control automaton, alternately assigns adaptive green light periods to traffic coming from each direction. The proposed fuzzy logic-based traffic controller has been compared with the conventional traffic control automaton featuring fixed-durations of green light intervals. The comparison has been carried out within a simulation environment for four different probability distributions of stochastic traffic flows at each end of the considered traffic corridor. Results have shown that the proposed fuzzy logic-based traffic controller performance is far superior to that of the conventional traffic control law in terms of achieving shorter vehicle queue lengths and less disparity in queue lengths for all considered simulation scenarios.*

## KEYWORDS

*fuzzy logic; simulation; railway traffic; scheduling; logistics; stochastic traffic flow.*

## 1. INTRODUCTION

Unforeseen or even planned infrastructural deviations may result in notable traffic slowdown or congested traffic conditions [1]. These may subsequently

create significant challenges for traffic control systems which need to preserve the traffic continuity and ensure its safe operation. Rail-based traffic may be particularly sensitive to such traffic limitations due to inherent infrastructure limitations and its particularities [2]. Moreover, the transportation sector is currently experiencing significant technological advances [3], including the introduction of novel automated people movers (APM's) and personal rapid transit (PRT) systems equipped with advanced propulsion systems.

These automated people movers and personal rapid transit systems have been extensively researched, with the initial idea given in reference [4]. The detailed analysis of such systems, presented in [5], dealt with their effectiveness and the possibility of integration into the urban multi-modal transportation. Reference [5] also indicated a significant potential for the increase in traffic capacity and sustainable operation. One possible implementation of such a PRT system is in local passenger transportation with connections to railway, bus, or airport terminals [6], along with the utilisation of novel fifth-generation (5G) telecommunications networks for vehicle routing. The effectiveness of such novel individual traffic entity-based personal transportation has been further demonstrated in [7] by successful implementation of one such system at the London Heathrow Airport in 2011.

Naturally, proactive vehicle distribution and traffic scheduling is key to maintaining viable traffic flows over the particular route, especially in the presence of traffic congestion [8]. In particular, reference [9] shows that by implementing advanced traffic organisation policies notable conservation of energy and reduction of carbon dioxide (CO<sub>2</sub>) footprint can be achieved. Implementation of such intelligent transportation systems (ITS) in railways has many benefits, from increased transportation capacity and utilisation of existing rolling stock to improvement of transport reliability and traffic safety, while also increasing energy efficiency and economic indices [10]. One such example is the application of an integer programming-based model that assesses the train capacity and travel time in order to produce optimised train timetables [11]. The benefits of utilisation of artificial intelligence and machine learning for improving the traffic flow, notably artificial neural networks (ANNs) and fuzzy logic, have already been recognised in road traffic applications [12], with particular emphasis given to the minimisation of queue lengths, as shown in references [13] and [14]. Moreover, ANNs have been successfully used for vehicle location prediction to increase transportation safety through communicating vehicle dynamic variables and navigation data between neighbouring vehicles [15]. The fuzzy logic-based approach has also shown great promise in transport routing optimisation [16], including those cases when emergency traffic re-routing is mandated by the occurrence of planned or incident-related traffic obstruction [17]. In particular, reference [17] shows that by adapting the duration of green light intervals for both directions of vehicle motion while utilising a single traffic lane (or railway track) to circumvent the traffic obstruction, a notable reduction of vehicle queues can be achieved compared to the traditional traffic control automaton with fixed green light interval durations.

Having this in mind, this work hypothesises that using a fuzzy logic controller in the case of traffic obstruction would result in significant vehicle queue reduction compared to the traditional approach for different traffic flow regimes. The particular fuzzy logic controller would re-route bidirectional traffic and circumvent the obstruction using a single obstruction-free traffic lane or railway track. Moreover, the proposed traffic scheduling approach would be suitable for local traffic control of personal rapid transport (PRT) systems implemented using

either actual two-way railways or their virtual counterparts [6]. The presented fuzzy logic-based traffic scheduling/control concept is tested by means of extensive simulations characterised by stochastic vehicle arrivals at the location of the traffic obstruction, modelled using different probability distributions.

The paper organisation is as follows. Section 2 outlines the PRT system and the topology of its bidirectional railway system or traffic lanes with fixed corridors emulating a virtual railway. Section 2 also formulates the problem of PRT vehicle two-way routing for the case of one rail line (or corridor) segment being obstructed. Section 3 presents a fuzzy logic controller for traffic scheduling aimed at maintaining balanced queue lengths at each side of the traffic obstruction. Section 4 presents the comparative simulation results of the conventional (fixed time interval) traffic controller and fuzzy controller characterised by adaptive time intervals. Section 5 recapitulates the presented subject matter and provides the concluding remarks, along with possible directions for future research.

## 2. PROBLEM FORMULATION

This section first outlines the personal rapid transit (PRT) system and the considered topology of traffic lanes suitable for actual railways with equal traffic priorities or virtual railways for intelligent mini-buses, which is followed by the formulation of PRT vehicle two-way routing problem for the case of one traffic line segment being subject to an obstruction.

### 2.1 Personal rapid transit system with fixed traffic corridors

*Figure 1* shows one example of an autonomous personal transit (shuttle) system for public transport with possible connections to major railway and bus stations and other centres of activity such as airports [6]. It comprises a two-way “virtual railway” system that can support independent two-way traffic according to the novel virtual railway paradigm. The vehicle control and navigation system are powered by 5G technology with an Ericsson terminal in the 3.5 GHz band on an EasyMile vehicle equipped with an information platform [6].

*Figure 2* shows one of the prospective traffic network topologies suitable for such a transportation system. This transportation grid alignment



Figure 1 – An example autonomous personal transit system with Ericsson 5G terminal and information platform

### 2.2 Altered traffic flow in case of obstruction

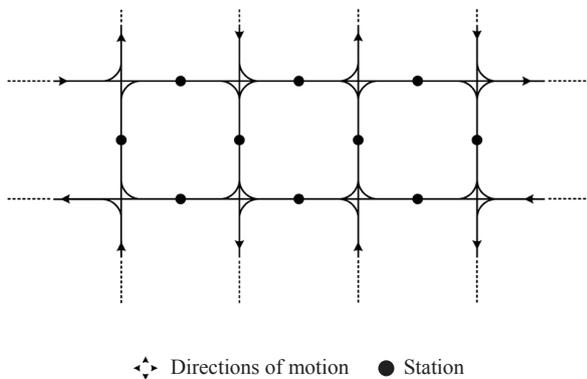


Figure 2 – One of the considered network topologies of a personal rapid transit system [4]

offers the possibility of directing traffic in all four directions and perpendicular to each other [4]. Using such a network topology, it would be possible to divert traffic in the case of planned traffic re-scheduling or unforeseen obstructions and provide traffic continuity under suitable traffic control over the problematic segment of the traffic network.

Figure 3 shows the particular segment of the PRT traffic network when one of the traffic corridors (rail lines) is obstructed, and, hence, unable to support the regular traffic flow. Since traffic from both directions can be diverted fairly easily using the considered traffic network topology (Figure 2), the left-to-right traffic (denoted as traffic direction 1) could be re-routed through the corridor intended for right-to-left traffic (denoted as traffic direction 2) thus bypassing the obstruction. Naturally, a traffic scheduling system is needed to control the vehicle flow, e.g. by using traffic lights as shown in Figure 3. In this way, a “green wave policy” (see [18]) can be alternately assigned to each traffic direction, thus reducing the traffic congestion and, ultimately, reducing the vehicle waiting queues  $N_1$  and  $N_2$  (i.e., number of vehicles waiting at each side). Speed limits may also be imposed to increase traffic safety, which is particularly important for the diverted traffic, which needs to perform several direction changes.

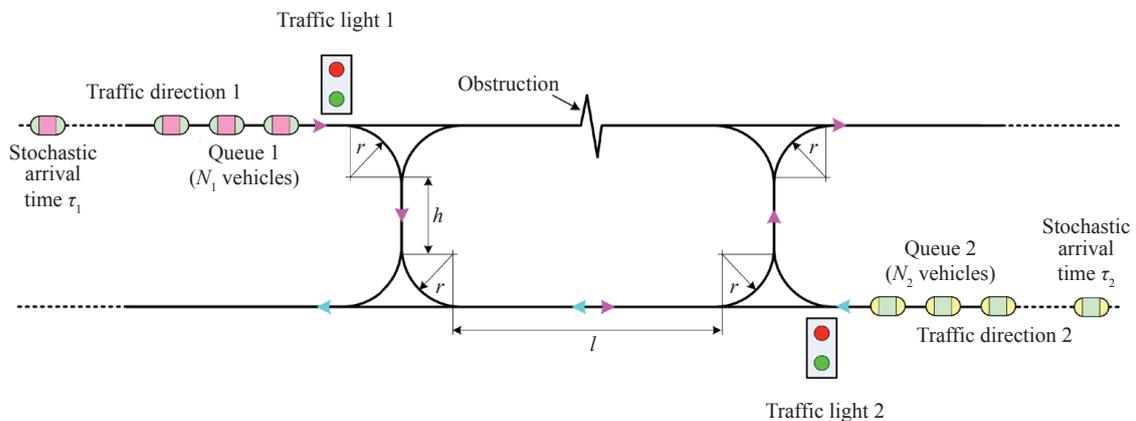


Figure 3 – Traffic network segment under obstruction with traffic flows and signalling (traffic lights) for both directions of motion

For left-to-right traffic (direction 1 in *Figure 3*) that needs to be diverted around the obstacle, vehicles need to traverse the following distance in order to arrive at the beginning of the unobstructed upper corridor (upper right corner in *Figure 3*):

$$L_1 = l + 2h + 2\pi r \quad (1)$$

with  $l$  being the horizontal segment length,  $h$  being the vertical segment length, and  $r$  is the curvature radius of the quarter-circle path travelled by the vehicle when turning from the horizontal to the vertical line segment and vice versa.

Similarly, in the case of right-to-left traffic (direction 2), i.e., the non-diverted traffic, the distance traversed by the vehicle to completely clear the particular traffic network segment is given as follows:

$$L_2 = l + 4r \quad (2)$$

For the sake of simulating the stochastic vehicle traffic flows for both directions, vehicle queue forming at each side of the obstructed network segment can be modelled by stochastic arrival times  $\tau_1$  and  $\tau_2$  of vehicles (wherein indices 1 and 2 correspond to previously defined directions of motion). Different stochastic processes may be considered for this purpose in order to provide different characteristic simulation scenarios (see the simulation results section).

### 3. FUZZY RULE-BASED TRAFFIC CONTROLLER

Fuzzy logic is commonly found in expert systems, wherein expert knowledge can be represented in the form of linguistic IF-THEN relationships (linguistic rules) [19]. Block diagram in *Figure 4* shows the fuzzy logic-based traffic control system comprising two identical fuzzy proportional-derivative (PD) controllers considered for minimising queue lengths  $N_1$  and  $N_2$  at each side of traffic network obstruction. Both controllers receive information on queue lengths, i.e., number of vehicles  $N_1$  and  $N_2$  waiting at opposite sides of traffic network obstruction (collected by an appropriate queue sensor system), and use these data to calculate the queue length disparities for both traffic directions (with  $k$  being the iteration step):

$$\begin{aligned} e_1(k) &= N_1(k) - N_2(k) \\ e_2(k) &= -e_1(k) = N_2(k) - N_1(k) \end{aligned} \quad (3)$$

The time-differences  $\Delta e_1(k)$  and  $\Delta e_2(k)$  of queue length disparities  $e_1(k)$  and  $e_2(k)$ , which are needed to establish the time-derivative action within fuzzy controller, are calculated as follows:

$$\begin{aligned} \Delta e_1(k) &= e_1(k) - e_1(k-1) \\ &= N_1(k) - N_2(k) - N_1(k-1) + N_2(k-1) \\ \Delta e_2(k) &= e_2(k) - e_2(k-1) \\ &= N_2(k) - N_1(k) - N_2(k-1) + N_1(k-1) \end{aligned} \quad (4)$$

Based on these input signals each fuzzy controller adapts the predefined (default) duration of green light  $T_0$  by its contribution, denoted in *Figure 4* as additive time intervals  $\Delta T_1(k)$  or  $\Delta T_2(k)$  calculated for each direction (1 and 2) and iteration step  $k$ . In particular, the fuzzy controller for direction 1 is active (enabled) for an even iteration step  $k$  whereas the fuzzy controller for direction 2 is active for an odd iteration step  $k$ . This is simply determined by modulo division with 2 (mod( $k$ ,2) block in *Figure 4*) of the iteration step  $k$ . The same result is also used to determine which direction of vehicle motion is going to receive a green signal light for the particular iteration step (*Figure 4*).

Linguistic rules defining the premise part of the fuzzy control law are given as follows:

$$\begin{aligned} \text{IF } e(k) \in \mu_i(e(k)) \ \& \ \Delta e(k) \in \mu_j(\Delta e(k)) \\ \text{THEN } y(i,j) &= g_{ij}(e(k), \Delta e(k)) \end{aligned} \quad (5)$$

with  $\mu_i(e(k))$  and  $\mu_j(\Delta e(k))$  being membership functions of queue disparity signal and its difference, and  $g_{ij}(\cdot)$  being output function values in the inference part of the fuzzy controller, which are herein defined as constant-valued solitons ( $g_{ij}(\cdot) = c_{ij}$ ).

The output of each PD fuzzy controller is calculated by using the following weighted sum (the so-called defuzzification block in each fuzzy controller in *Figure 4*) [19]:

$$y_{1,2}(k) = \Delta T_{1,2}(k) = \frac{\sum_{i=1}^4 \sum_{j=1}^4 \mu_i(e_{1,2}(k)) \mu_j(\Delta e_{1,2}(k)) c_{ij}}{\sum_{i=1}^4 \sum_{j=1}^4 \mu_i(e_{1,2}(k)) \mu_j(\Delta e_{1,2}(k))} \quad (6)$$

with  $\Delta T_{1,2}(k)$  representing the adaptive duration of green lights, as explained above.

Membership functions  $\mu_i(e_{1,2}(k))$  and  $\mu_j(\Delta e_{1,2}(k))$  and the constant-valued solitons  $c_{ij}$  of the proposed dual fuzzy controller are shown in *Figure 5*, and they correspond to the following membership sets of controller input signals  $e_{1,2}(k)$  and  $\Delta e_{1,2}(k)$ : ZN (Zero or Negative), SMP (Small to Medium Positive), MLP (Medium to Large Positive), and LP (Large Positive). In particular, membership functions are either trapezoidal (ZN and LP sets) or triangular (SMP and MLP sets), as shown in *Figures 5a and 5b*. Solitons  $c_{ij}$  in the output (inference) part of the fuzzy control

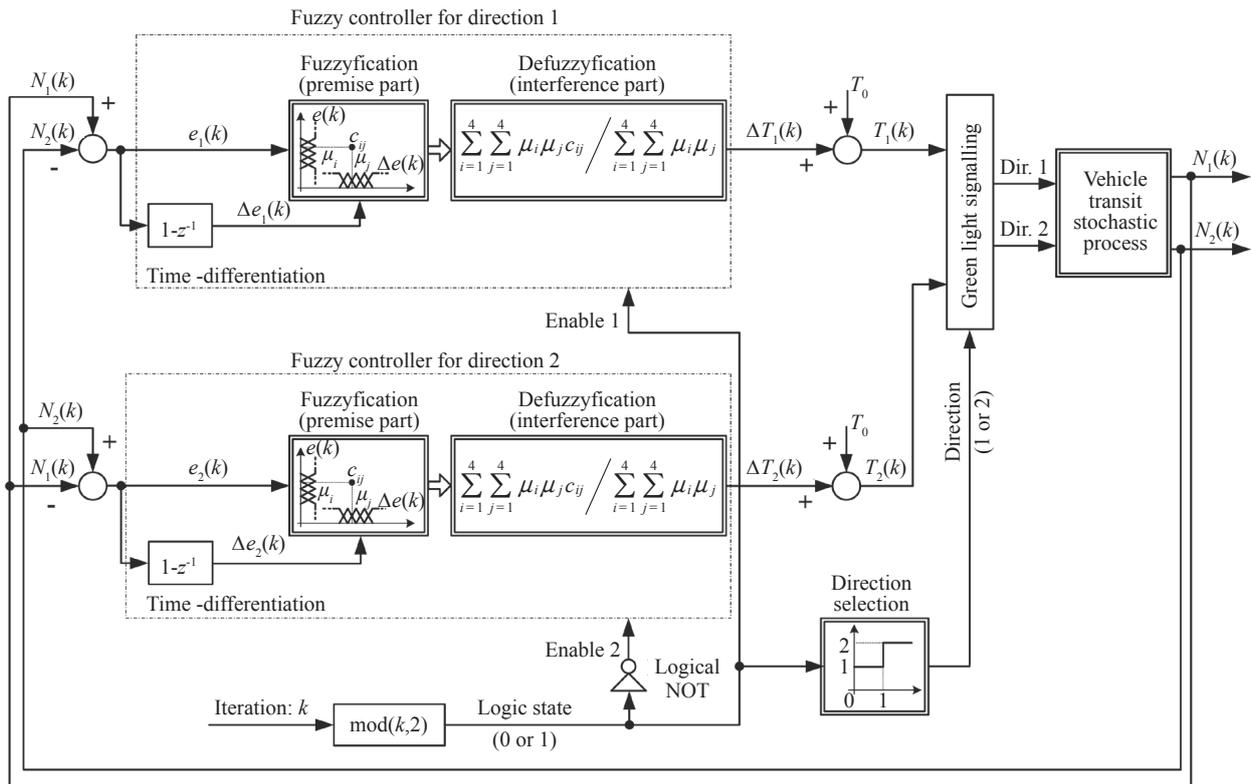


Figure 4 – Block diagram representation of fuzzy logic-based traffic scheduling system for partially obstructed traffic network using dual fuzzy logic controllers

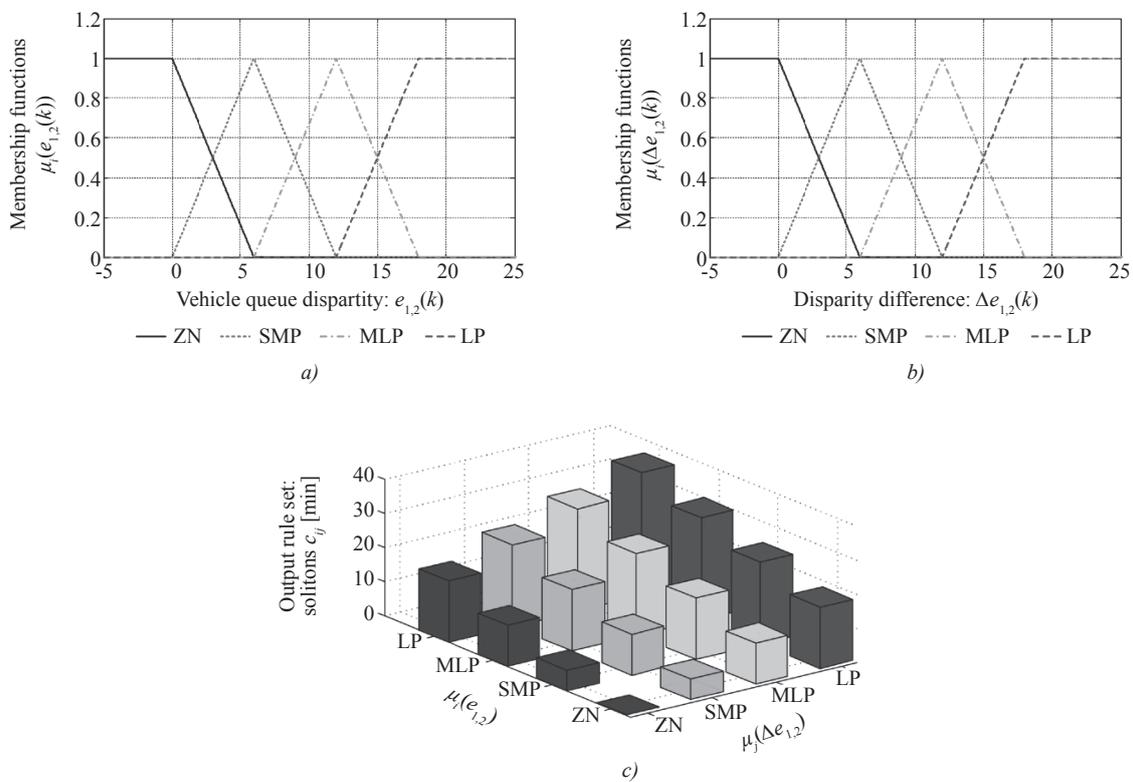


Figure 5 – Membership functions of the fuzzy controller with respect to queue disparity signal (a) and disparity difference (b), and output rule solitons (c)

law (Figure 5c) assign greater weights to greater values of vehicle queue disparity  $e_{1,2}(k)$  and its difference  $\Delta e_{1,2}(k)$ , and vice versa.

#### 4. SIMULATION RESULTS

The proposed dual fuzzy logic controller for control of partially obstructed traffic has been validated and compared against a conventional traffic controller through simulations, wherein stochastic vehicle arrival times are modelled by four different probability distribution models. In that respect, the conventional traffic controller (used herein as a benchmark) accounts for the different lengths of vehicle paths for directions 1 and 2, wherein direction 1 is characterised by a longer path to be traversed due to diverted traffic. This path length difference can be expressed by the following ratio of distances traversed by the vehicle, which is defined based on equations 1 and 2:

$$\alpha = \frac{L_1}{L_2} = \frac{l+2h+2\pi r}{l+4r} \quad (7)$$

For the considered simulation setting, the following traverse length values are chosen:  $L_1=1.5$  km and  $L_2=1$  km. This results in the traversed distance ratio  $\alpha=1.5$ . Moreover, the average vehicle speed of 30 km/h is imposed for both directions of motion in a particular case study. Therefore, when the conventional traffic control system is used (with fixed durations of green light intervals), the above traversed distance ratio  $\alpha$  can be used to define the time interval duration of green light  $T_{L1}$  for vehicles travelling in direction 1 with respect to the green light interval duration  $T_{L2}$  for vehicles travelling in direction 2:

$$T_{L1} = \alpha T_{L2} \quad (8)$$

The overall model and the selected traffic control laws are simulated within Matlab software environment [20]. The simulation scenarios have included the following two cases [17]:

- 1) Fixed green light intervals proportional to transition time ( $T_{L2}=10$  min,  $T_{L1}=\alpha T_{L2}=15$  min);
- 2) Fuzzy logic-based green light adaptation, with base time interval  $T_0=10$  min.

In the considered simulation scenario, vehicle arrival times  $\tau_1$  and  $\tau_2$  for vehicles arriving from the left (direction 1) and vehicles arriving from the right (direction 2) have been simulated as stochastic processes characterised by probability density functions listed below (see [21] for a more detailed description of considered probability distributions).

- Normal (Gaussian) probability density function:

$$p(\tau_{1,2}) = \frac{1}{\sigma_{1,2}\sqrt{2\pi}} \exp\left[-\frac{1}{2}\left(\frac{\tau_{1,2}-\tau_0}{\sigma_{1,2}}\right)^2\right], \tau_{1,2} \geq 0 \quad (9)$$

where  $\sigma_{1,2}$  is the standard deviation of vehicle arrival times from its mean value  $\tau_0$ .

- Exponential probability density function:

$$p(\tau_{1,2}) = \lambda \exp(-\lambda\tau_{1,2}), \tau_{1,2} \geq 0 \quad (10)$$

with  $\lambda$  being the so-called spread factor.

- Uniform probability density function:

$$p(\tau_{1,2}) = \begin{cases} \frac{1}{b-a}, & a \leq \tau_{1,2} \leq b \\ 0, & \text{otherwise} \end{cases} \quad (11)$$

with  $a$  and  $b$  being the sample minimum and maximum value, respectively.

- Poisson probability density function, commonly used for discrete event modelling in traffic applications [22]:

$$p(\tau_{1,2}) = \frac{\lambda^\tau}{\tau_{1,2}!} \exp(-\lambda), \tau_{1,2} \geq 0 \quad (12)$$

with the probability of an event defined by the average occurrence rate  $\lambda$ .

Figure 6 shows the probability density function plots for the considered stochastic processes modelling arrival times for both directions of motion. Since vehicle arrival times  $\tau$  can only be positive ( $\tau \geq 0$ , as indicated in equations 9–12), probability density functions are not defined for negative  $\tau$  values. Therefore, negative  $\tau$  values are truncated from the probability distribution, as shown for the case of normal probability distribution in Figure 6a. Moreover, by using the above listed probability distributions in the simulation of vehicle arrival times, the robustness of the proposed traffic control system can be systematically tested. Namely, the normal probability distribution, and especially the exponential probability distribution are likely to favour smaller arrival times (more frequent arrival of vehicles), due to their maxima being at lower arrival time values (cf. Figures 6a and 6b). On the other hand, the uniform distribution has an equal probability of both small and large vehicle arrival times (cf. Figure 6c), whereas the chosen Poisson distribution concentrates vehicle arrival times over a narrow range (cf. Figure 6d).

The comparative simulation results for the above considered stochastic processes with probability distributions of vehicle arrival times given by equations 9–12, are shown in Figures 7–10.

Figure 7 shows the comparative results of the fuzzy logic-based controller and conventional traffic controller for the case of normal (Gaussian) probability distribution of vehicle arrival times. The

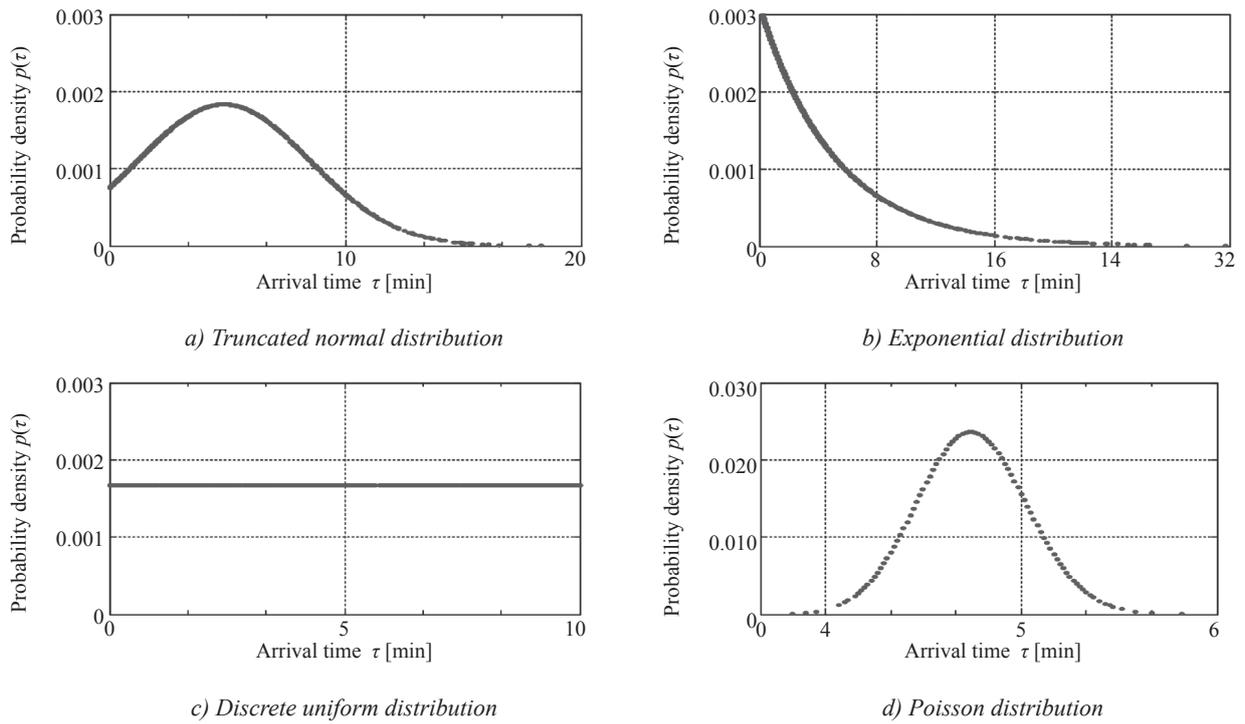


Figure 6 – Shapes of probability density functions  $p(x)$  used for simulation of stochastic vehicle arrival times

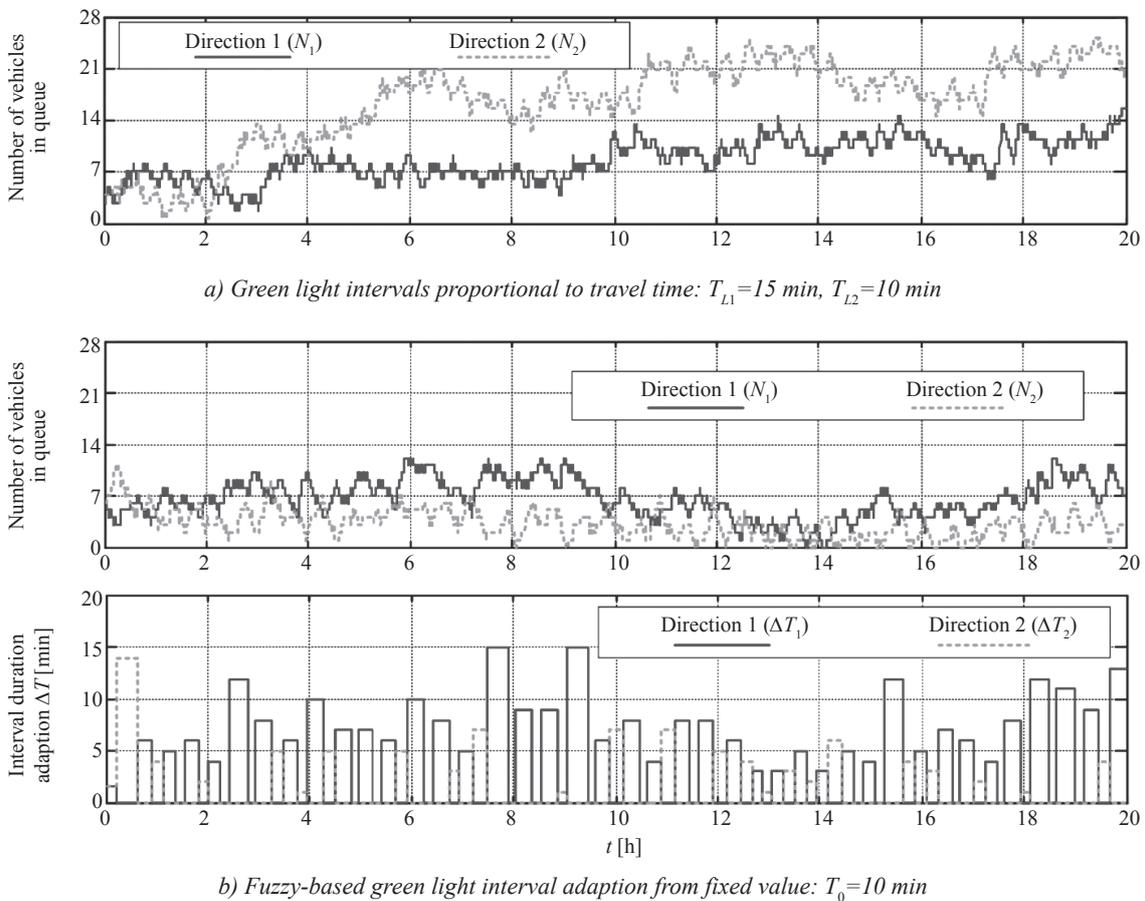


Figure 7 – Results obtained with fixed time transition intervals (a) and fuzzy controller-based transition intervals adaption (b) for the normal probability distribution of vehicle arrivals

results in *Figure 7a* show a notable drift of both vehicle queues towards greater queue lengths, as well as increasing disparities between vehicle queues  $N_1$  and  $N_2$  in the case when conventional traffic controller is used. The fuzzy logic-based controller, on the other hand, is capable of both significantly reducing the vehicle queue lengths and to effectively suppress the aforementioned vehicle queue length drift (see upper plott *Figure 7b*). This is achieved through adaptation of green light durations for both directions of motion (see lower plot in *Figure 7b*). It is also worth noting that direction 1 (characterised by traffic obstruction) requires significantly longer green light duration (lower plot in *Figure 7b*) which is directly associated with the requirement to detour (re-route) the related incoming traffic.

The comparative simulation results of the fuzzy logic-based and the conventional traffic controller for the case of the exponential probability distribution of vehicle arrival times are shown in *Figure 8*. In this case, the application of conventional control automaton results in substantial disparity between vehicle queue length  $N_1$  (direction 1) and queue length

$N_2$  (direction 2) which may exceed 20 vehicles, as indicated by simulation traces in *Figure 8a*. Such a large difference in queue lengths, in particular long queues affecting direction 1 can be attributed to combined effect of longer traversed path of re-routed vehicles from direction 1, along with the stochastic nature of vehicle arrivals that the non-adaptive traffic controller cannot accommodate for. Again, when fuzzy logic control is used to effectively adapt the green light interval durations, significantly smaller disparity in queue lengths is observed between the two traffic directions (*Figure 8b*).

*Figure 9* shows the simulation results for the case of uniform probability distribution of vehicle arrival times. Again, as in the previous cases, the conventional traffic controller cannot prevent notable vehicle queue drift in the case of direction 1, characterised by longer vehicle traverse path, and the notable disparity of queue lengths between direction 1 and direction 2 (see *Figure 9a*). As expected, when fuzzy logic-based controller is used, it is capable of adjusting (adapting) the green light durations for both

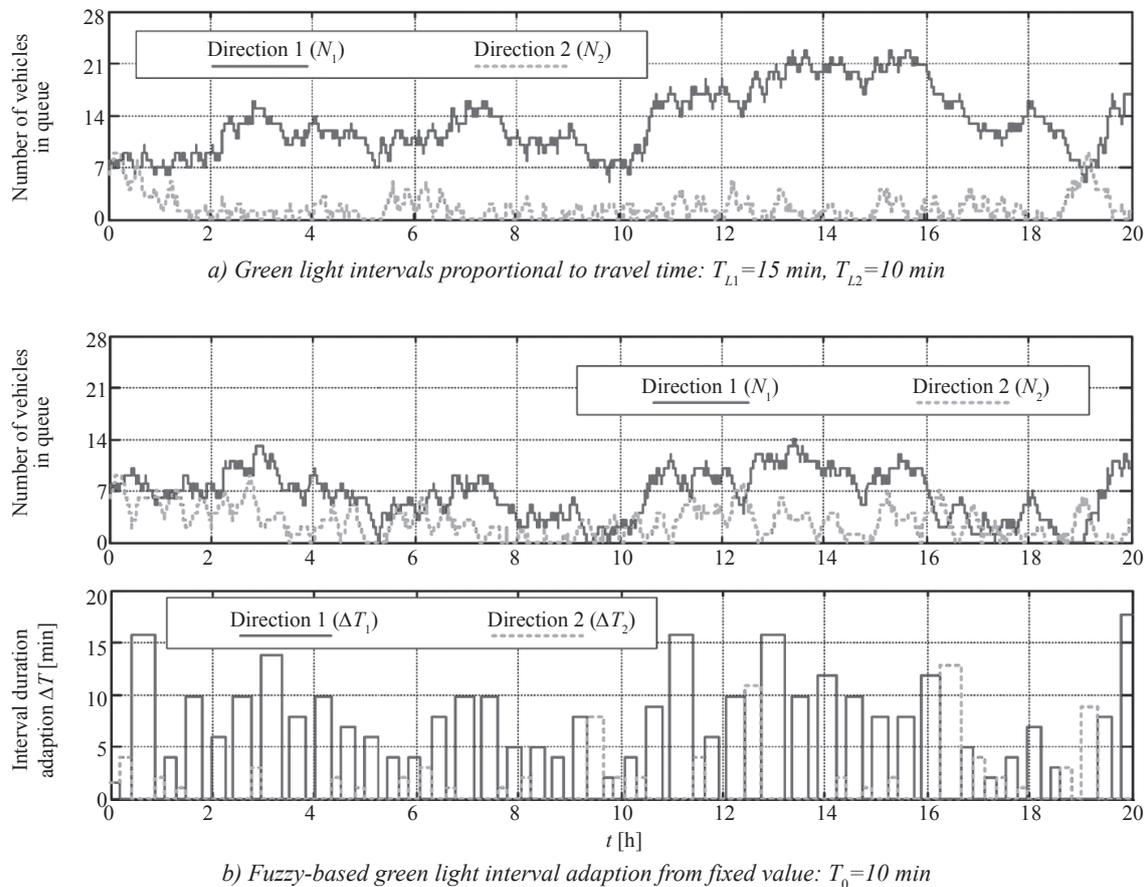


Figure 8 – Results obtained with fixed time transition intervals (a) and fuzzy controller-based transition intervals adaptation (b) for the exponential probability distribution of vehicle arrivals

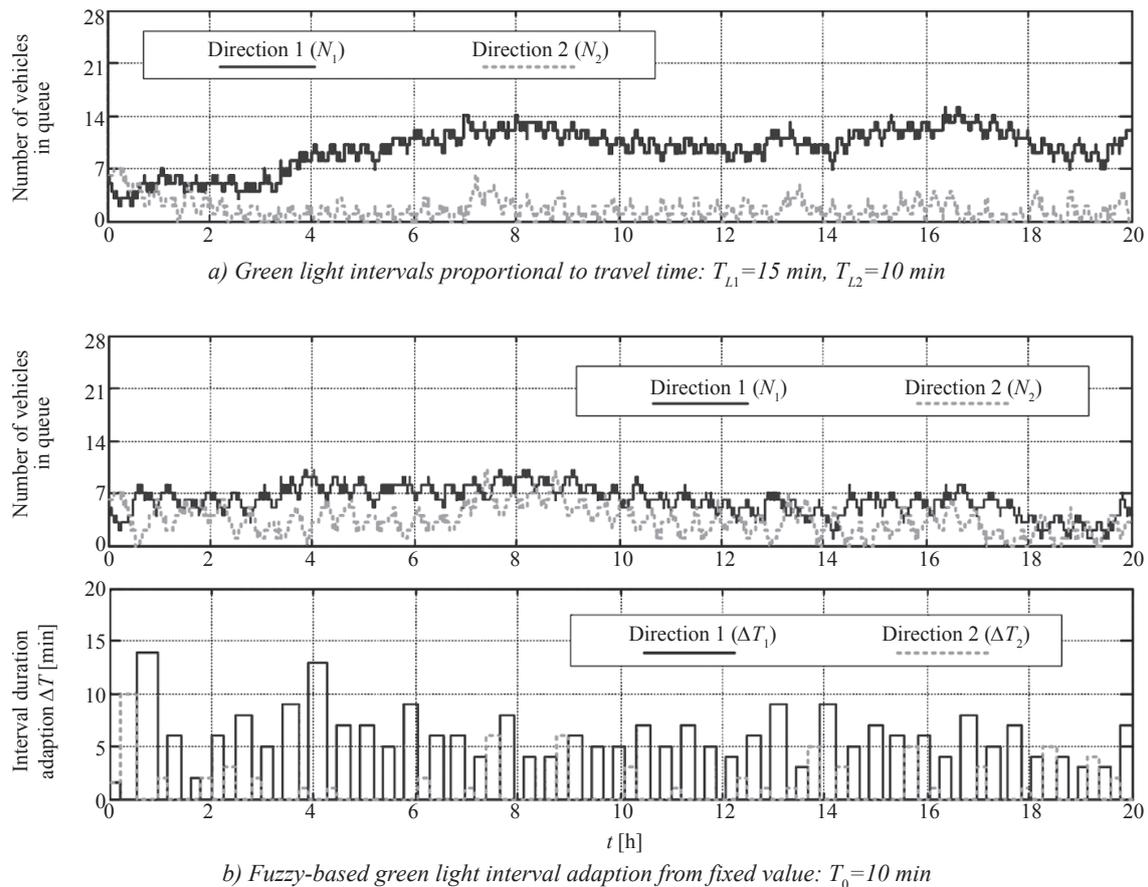


Figure 9 – Results obtained with fixed time transition intervals (a) and fuzzy controller-based transition intervals adaptation (b) for the uniform probability distribution of vehicle arrivals

directions of motion in order to achieve acceptable vehicle queue lengths, along with small differences of vehicle queue lengths (Figure 9b).

Finally, Figure 10 shows the comparative simulation results for the case of Poisson probability distribution of vehicle arrival times. Figure 10a shows that in the case of Poisson probability distribution a linear-like increase of number of vehicles in queue is observed for direction 1, whereas direction 2 is characterised by relatively short vehicle queues. This again points to the incapability of the conventional (non-adaptive) control law to effectively deal with stochastic vehicle arrival times. As the results in Figure 10b attest, the fuzzy logic-based controller, being capable of systematically and effectively adapting the duration of green light intervals, can both reduce the vehicle queue length for direction 1, and simultaneously achieve similar queue lengths for both directions of motion throughout the particular simulation scenario.

The results clearly indicate the superior performance of the dual fuzzy logic-based traffic control system, which can deal with the stochastic

vehicle arrivals more effectively than the conventional fixed-duration traffic control law. This improvement is comprehensively achieved by selecting suitable linguistic rules in the premise part of the fuzzy control law and output weights in its inference part.

Figure 11 summarises the results in Figures 7–10 through comparative average steady-state vehicle queue lengths (obtained for the last two hours of operation of traffic controllers) for conventional timer-based logic and fuzzy logic control. It is observable that the utilisation of conventional (fixed time interval) traffic controllers results in significant discrepancies between lengths of vehicle queues on the opposite sides of the traffic obstruction, whereas the application of fuzzy logic-based controller results in vehicle queue lengths being more uniform and much shorter in all cases. In particular, the greatest improvement with respect to the reduction of vehicle queue length drift is achieved for the case of the truncated normal probability distribution of vehicle arrival times (Figure 11a), and the case of Poisson probability distribution (Figure 11d). The other two simulation scenarios, corresponding to the

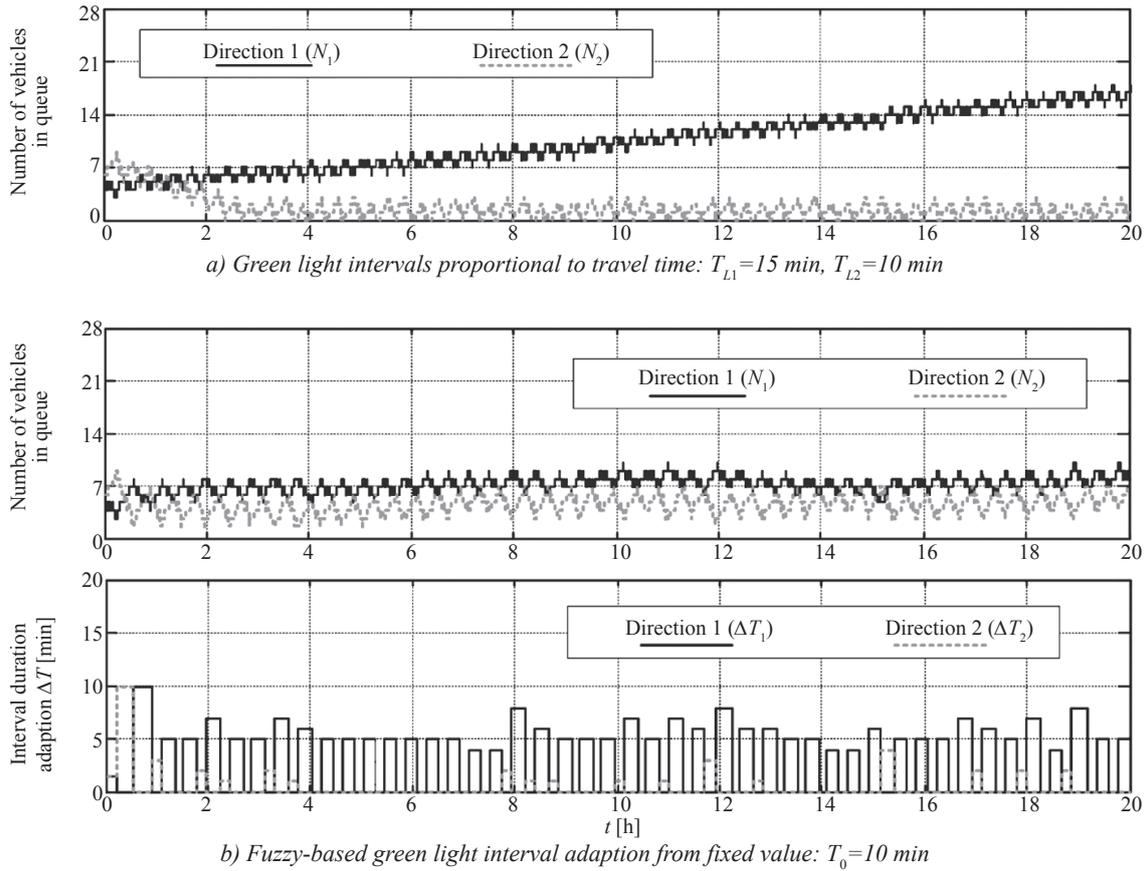


Figure 10 – Results obtained with fixed time transition intervals (a) and fuzzy controller-based transition intervals adaption (b) for the Poisson probability distribution of vehicle arrivals

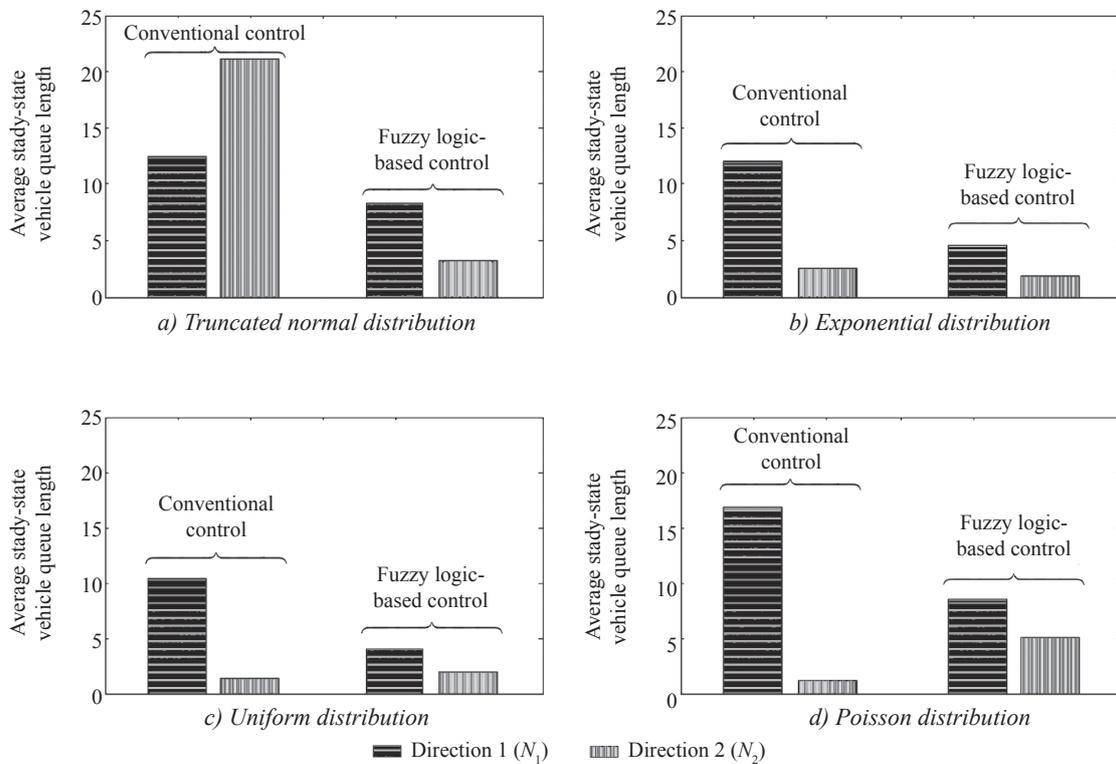


Figure 11 – Comparison of average steady-state vehicle queue lengths for conventional and fuzzy logic-based control for different vehicle arrival probability distributions

exponential probability distribution (*Figure 11b*) and uniform probability distribution (*Figure 11c*), are characterised by somewhat less emphasised lengths of average vehicle queues when conventional traffic control is used. Nevertheless, the fuzzy logic-based controller is also capable of achieving significant reduction of vehicle queue length disparity in both of the aforementioned cases, even resulting in similar average queue lengths for these particular cases (see *Figures 11b and 11c*).

## 5. CONCLUSION

This paper has presented a fuzzy logic-based traffic scheduling algorithm aimed at reducing traffic congestion. The control law has been developed for the case of partial obstruction of a bidirectional traffic lane characterised by fixed vehicle paths. The proposed proportional-derivative (PD) fuzzy control algorithm has been set up to alternately assign variable green light periods to traffic coming from each direction, thus effectively adapting the green wave policy depending on the disparity of vehicle queue lengths. The proposed fuzzy logic-based adaptive traffic controller has been compared with the conventional traffic control automaton with fixed-duration of green lights for different stochastic traffic flow scenarios described by normal, exponential, uniform and Poisson probability distributions.

The comparative simulation results have pointed to the following advantages of the fuzzy logic-based controller with respect to the conventional control law: (i) utilisation of fuzzy logic control can notably reduce the drift of queue lengths for both directions of motion, and (ii) it can also reduce the disparities between queue lengths for all considered simulation scenarios. Moreover, significant improvement has been observed with respect to reduction of average queue lengths, especially for the cases of the normal and Poisson probability distributions of vehicle arrival times. The cases of exponential and uniform probability distribution, being characterised by somewhat smaller average queue lengths in the case of conventional traffic control, have also shown a notable potential for traffic flow improvement (and shortening of vehicle queues) when fuzzy logic-based controller has been used. These improvements in traffic control performance are due to the ability of the fuzzy logic-based control law to systematically adapt the durations of green light intervals through appropriately chosen linguistic rules in the premise part and output weights in its inference part.

Future work may be directed towards further optimisation of the fuzzy logic-based traffic control law, with respect to probabilistic properties of incoming vehicle stochastic traffic flows.

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## **UPRAVLJANJE PROMETNIM ENTITETIMA U PRIVREMENO OGRANIČENIM PROMETNIM UVJETIMA PRIMJENOM SUSTAVA NEIZRAZITE LOGIKE**

### **SAŽETAK**

*U radu je prikazan dizajn sustava upravljanja prometovanjem vozila zasnovanog na neizrazitoj logici s ciljem smanjenja zagušenja prometa za slučaj djelomičnog prekida prometa na dvosmjernom prometnom traku. Ovakav problem se tipično susreće u željezničkom prometu i sustavima za brzi prijevoz osoba sa predefiniranim fiksnim prometnim koridorima. Predloženi proporcionalno-derivativni (PD) regulator zasnovan na neizrazitoj logici, a koji služi kao automat za upravljanje prometom, naizmjenično dodjeljuje i adaptira intervale slobodnog prolaska prometu koji dolazi iz oba smjera. Predloženi regulator prometa zasnovan na neizrazitoj logici uspoređen je s konvencionalnim automatom za upravljanje prometom koji dodjeljuje fiksne intervale slobodnog prolaska vozila. Usporedba je provedena u simulacijskom okruženju za četiri različite vjerojatnosne razdiobe stohastičkih prometnih tokova na svakom kraju razmatranog prometnog koridora. Rezultati su pokazali da je predloženi regulator prometa zasnovan na neizrazitoj logici daleko nadmoćniji u usporedbi sa konvencionalnim pravilom upravljanja u smislu postizanja kraćih redova čekanja vozila i manjih razlika u duljinama redova čekanja za sve razmatrane simulacijske scenarije.*

### **KLJUČNE RIJEČI**

*neizrazita logika; simulacija; željeznički promet; upravljanje prometom; logistika; stohastički prometni tok.*

## ACKNOWLEDGEMENT

The presented research has been supported by the European Regional Development Fund under the grant KK.01.1.1.01.0009 (DATAACROSS).

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