Type-II Fuzzy Membership-Based Traffic Congestion Control For URBAN Areas

HANSBIR KAUR SUPREET KAUR

Abstract : Control of traffic congestion is a challenging issue in urban areas. With the advancements in towns, the number of motors has been increased at a rapid rate. Much potential time is wasted due to traffic jams. The prime reason behind the traffic congestion is that the traffic signal timings are constant. Therefore, handling this issue is still defined as an ill-posed problem. A new generation referred to as Radio Frequency Identification (RFID) is added which may be combined with the existing signaling machine. It can act as a key to smart visitors control in real-time. This new generation with a view to require much less time for set up with lesser prices as compared to different techniques of site traffic congestion management. However, it suffers from the uncertainty issue. Therefore, in this paper a novel, Type-II fuzzy based congestion control system is proposed to control urban traffic. Extensive experiments reveal that the proposed technique outperforms the existing technique.

Keywords: Traffic congestion, Necessity of signal, Urban Traffic Control, RFID, Internet of things.

1. INTRODUCTION
The urban traffic congestion has become a global phenomenon. These days, urban arterials are being called upon to carry more users than ever before. The users of these facilities are growing more complex (younger and older drivers, more distractions, larger vehicles, etc.) and the demand for such use continues to outpace transportation supply. Road traffic congestion is a critical problem accelerated by an exponential growth in the number of vehicles, ceaseless urbanization and has become a phenomenon visible in urban area of developing south Asian countries like India. According to the World Population Report by United Nations 2017 revision the population of the world is 7.6 billion in 2017 and it is expected to touch at 11.8 billion in year 2050. India will become world most populous nation by overtaking China in year 2030. In India, a developing country and home of around 1.3 billion people the problem of rapid urbanization and vehicular growth is considerably more severe. The resulted traffic congestion increases delay, energy consumption, environmental pollution and vehicle operation cost (VOC). In view of the increasing traffic problem, heterogeneous nature of moving vehicles and lack of possibilities for infrastructure expansion in urban road networks, the optimal use of available road space can be judiciously achieved by efficient signal control strategies. According to the information available for traffic light on Wikipedia the origin of traffic control signals can be traced back to the manually operated semaphores first used in London by engineer J.P. knight as early as on 9th December 1868. The use of this signal was discontinued due to gaseous explosion. Then after the first electric traffic signal was developed in the United States by James Hodge and installed in Cleveland, Ohio, in 1914 (FHWA, 1996). This was followed by the introduction of interconnected signals in 1917 in Salt Lake City, Utah, U.S.A.

Automatic control of interconnected traffic lights was first introduced in March 1922 in Texas, U.S.A. Since 1914 when the first electronic traffic signal in the U.S. was erected, there has been no doubt about the significance of what a smart and efficient traffic signal control system can do for the society. As the vehicular traffic increases day-by-day in the cities, it becomes necessary to signalize the intersections of arterial/sub-arterial streets to control and regulate the traffic. It is just not enough to install the signals on intersections to satisfy one or more warrants. By installing the signals and applying proper phase plans, there is considerable reduction in conflicting points, which ensures reasonable safety. So, the main consideration should be given to reduce the delay to vehicles on the legs of intersection. Signal coordination is a tool available in the hand of traffic engineers by means of which they control, regulate and manage the traffic in the signal system in such a way the most productive and cost-effective use of the existing roadway system can be made. A good knowledge of road user characteristics, vehicular characteristics, Traffic flow characteristics, roadway and environmental characteristics is necessary for traffic engineers to arrive at meaningful decision for effective coordination. When traffic signals are in proximity, the presence of the upstream traffic signals alters the arrival pattern of traffic at the downstream traffic signals from random arrivals to arrivals in platoons. This means that improved traffic flow can be achieved if the green signal at the downstream traffic signal is arranged to coincide with the arrival of the platoon. To achieve this, traffic signals are coordinated, sometimes called “linked”. Coordination is achieved through three features: Typically, the first two of these factors remain unchanged for many years. However, the other three may change from one day to the next day and several times within a day. Green signals at adjacent intersections are set to occur at a given time, relative to that at a reference intersection. It depends on the distance between signals, the progression speed along the road between the signals and the queues of vehicles waiting at red signals. If this time offset is set properly, then coordination of the signal can be achieved as depicted in the following Figures 1 (a) and 1(b).
Present urban traffic control systems techniques work with information bought through various alerts found in distinct things on the highway commercial infrastructure. Information on the road weight and existing urban traffic intensity is generally offered by urban traffic keeping track of cameras. To carry out site visitor's management, it is very important use a two-way transmission on the watched car or truck with the site visitor's management heart. modules plus obtain things are found end route. The results compiled from moving autos because of the obtain things is deliver to an avid database inside the clouds. The process of the actual traffic control system management process works on primarily about the keeping track of plus managing of car traffic control system which will converse with the system. You are able to management the actual circulation with traffic control system by means of traffic control system laments in order to rapidly enlighten traffic control system contributors regarding crashes. The unit might point to option avenues in order to avoid traffic control system accidents and perchance to just make another solution highway as a result of proper signaling. It is usually easy to analyze the stress of a offered highway and also block. By way of acquiring details from many autos, it may monitor any highway plus direction autos to side to side in case of a large weight. Any refined algorithm with traffic control system detection which in turn redirects autos in the case of serious weight is displayed with Fig. 2. Your research into the direction and its option for the car or truck will be determined not merely by boundaries with the auto or possibly a road. Particularly, it ought to foresee the stress upon a certain direction with a offered time. RFID (Radio Frequency Identification) know-how can tremendously enhance visitor’s management. Specifically, this is applicable to intelligent identity connected with vehicles. The actual contactless identity program works extremely well by 50 percent ways. From the typical method, RFID tags will be positioned in motor vehicles and also readers items are positioned in highway system [9]. So, it's possible to understand important information from the vehicle. The actual identifiers are usually developed from the fabrication period to include details on the car identity amount, unit, engine form, form of energy, and a lot more. The actual system from the program resembles one referred to around p. 3, but the introduction of the RFID strategy is a fundamental novelty. Complete identity of human motor vehicles and also their location comes about from RFID throughways placed from a few points from the system, where automobile RFID transponders will be read. In the case of locations along with constraints, it's possible to make use of dedicated highway obstacles along with RFID readers. Every automobile can be given an original identity amount placed within the RFID transponder. The actual getting close to automobile can be recognized and also the details recovered by the target audience weighed against the collection files to see if the car can be certified to penetrate a particular minimal area. If you do, the filter can be brought up, permitting the car to penetrate. The use of RFID grows the protection from the program and its integrity. A specialized method not really utilized can be investing in RFID tags within the highway floor as well as within the roadside and RFID visitors positioned in vehicles. The internet of things is a wide-ranging vision in which the Web sees everyday things where physical things inside the electronic entire world grow to be feasible remotely. This idea regarding internet of things opens terrific options for your financial state and improvement of the universe and involving individuals [1]. Internet-based info allows the swap regarding "things", like solutions and goods, and gives an i.t facilities inside a secure and safe manner. Actual things like motors, umbrellas among others include explore the regular task regarding people solutions, trading exercises and into their lives within metropolitan areas and pavements and they're able to convey and interact with these equipment and systems [2]. There are many examples of parking systems which include motors lower targeted traffic jams. This research newspaper discusses using internet of things in cutting targeted traffic jellies when shopping for clean parking gaps intended for motors via an extensive system composed of delicate equipment named receptors this are widely-used to perception motors if parked and send information via an association device that can take the data with the sensor / probe via Wi-Fi in an individual can reasoning computing. The idea may also have a new cell phone program which often links together with the reasoning showing the data coming from receptors and individuals can simply be aware of clean parking using their own phones.

2. RELATED WOK

Andreas et al. (2008) have carried out survey to cover the research in the area of adaptive traffic control with emphasis on the applied optimization methods. Method uses Bi-level formulation, and dynamic for the online. There are several models for trace networks, which are not based on the periodic behavior of online systems to perform coordination. Instead they assign green time to phases in some order, which is optimal given the detected and predicted trace. Kadiya (2010) have first presented a methodology to coordinate the signals for four arm intersections in two-way directions on the busy urban corridor for typical Indian condition. They have suggested phase plan A and B comparing their suitability for the satisfactory coordination in odd and even phase differences between two 4 arm intersections. A strategy is fixed to select suitable phase plan, according to odd or even phase difference for better two-way coordination. Patel K. M. (2011) has presented a methodology to coordinate the
signals in four-way direction on the busy urban corridors preparing time-space diagram in AutoCAD. They have proposed phase plan A, B and H for better coordination of the selected network. Using actual road network traffic data for the four-way signal coordination, has calculated delay in AutoCAD and MS Excel, compared these two delays and found that there may be considerable reduction in overall delay by four-way coordination. Shah et al., (2013) have discussed that in the studies on site implementation of optimization of phase offset or virtual implementation of developed method were not performed through simulation software. Varia et al., (2012) in their paper (received most cited paper award in December 2016 by Elsevier) used the genetic algorithms technique for joint optimization of signal setting parameters and dynamic user equilibrium (DUE) traffic assignment for the congested urban road network. The proposed method is applied to the real network data of Fort Area of Mumbai city (India) comprising of 17 nodes and 56 unidirectional links with 72 Origin–Destination pairs, where all the 17 nodes are signalized intersections. Janrao et al., (2017) have given necessity to efficiently manage the traffic flow by completely utilizing the existing capacity of the road. Modern Cities are facing a lot of trouble due to the traffic congestion. Increasing population results in subsequent increase in the vehicles causing congestion. Traffic jams and congestion create several issues like wastage of time, excess fuel consumption. In emergency cases, the ambulance boarding a critical patient cannot reach the destined hospital on time due to the congestion, where every second counts. Fluren (2017) has compared signal coordination strategy of pre-timed control versus adaptive control for high traffic conditions. When the intersection cannot (or can just barely) handle the amount of traffic arriving at it, it becomes of extreme importance to use the intersection as effectively as possible; for some phase sequences (order of green intervals) the intersection can be used more efficiently than for others because for these sequences the time wasted on clearance times is smaller and, therefore, more time is available for green intervals. Chang-qiao et al. (2012) have suggested a method to estimate SFR and observed that when saturation headway distribution is symmetrical the proposed method gives consistent result with the traditional approach. Williamson et al., (2018) has studied safety impact of signal coordination along urban arterial at Mount Vernon, Illinois in the United States. The study identified the safety benefit from traffic signal coordination projects on major arterial roadways through urban areas using a before and after study with a comparison groups approach and a meta-analysis method. The findings suggest that traffic signal coordination could decrease total crashes by 21 percent, injury crashes by 52 percent and property-damage-only crashes by 21 percent.

The review has shown that most of the existing technique has neglected the following issues.

1. The performance of the RFID depends upon the decision variables; however, binary decision variables lead poor results.

2. The fuzzy logic does not guarantee the best solution for uncertain cases, but rich because of its multivalent logic.

3. The use of the Type-II fuzzy logic is ignored to efficiently control the congestion of traffic in urban areas.

Therefore, using the Type-II fuzzy based congestion control system is the main motivation of this research works.

3. PROPOSED ALGORITHM

Figure 2 shows the proposed methodology.

Type-1 Fuzzy sets: A new type-1 fuzzy set, A new may be portrayed mathematically when:

Otherwise, it is continual, fuzzy set A new may also be portrayed when:

Expressed mathematically as:

Here, \( \int \) means integrated, total the actual admissible \( x \) and it's the actual member's program of each and every factor \( x \in X \). The actual purpose involving fuzzy places be more well known in almost any use or real-world case in point if you experience every hide plus hazy knowledge regarding the technique parameters. In order to model this kind of apps, it can be on the way of characterizing a few or every one of the parameters by using fuzzy numbers.

(ii) Fuzzy Numbers: A fuzzy number \([3]\) is a fuzzy set \( \mu: R \rightarrow [0,1] \) on \( R \) satisfying:

i. \( \mu \) is upper semi continuous.

ii. supp \( \mu \) is closed and bounded interval.

iii. if \( \text{supp } \mu = [a,b] \), then there exist \( c, d \) such that \( a \leq c \leq d \leq b \) such that \( \mu \) is increasing on the interval \([a,c]\) equal to 1 on the interval \([c,d]\) and decreasing on the interval \([d,b]\).

The support \([7]\) of a fuzzy set \( A, S(A) \), is a crisp set of all \( x \in X \) such that \( \mu_A(x) > 0 \)

(iii) Type-2 Fuzzy Sets \([4-6], [36-37]\): A type-2 fuzzy set, denoted by \( \tilde{A} \), is characterized by a type-2 membership function.
function \( \mu_r \) where \( x \in X \) and \( x \in f_x \leq [0,1], i.e \\
\hat{T} = \{(x,u), \mu_r(x,u) \} \forall x \in X, \forall u \in f_x \leq [0,1], 0 \leq \mu_r(x,u) \leq 1 \ldots \ldots \ldots \ldots (3) \\

Right here, \( x \) is actually a primary diverse and its particular statistic area; \( f_x \) is actually denoted by \( x \). \( u \in f_x \) at each and every ; is actually a primary member's program level of can portrayed seeing that:

Type-2 fuzzy packages permit improved behaving relating to disbelief given that type-2 fuzzy (T2FS) packages add your Result relating to Concern (FOU). FOU is perhaps belonging to the lastly element from the T2FS which undoubtedly allows more degrees of freedom for you to T2FS when compared to type-1 fuzzy sets. In general instance involving fuzzy arithmetic, many magazines have demonstrated that will T2FS can outperform the type-1 FSs brethren in a range of applications. Similarly, T2FS can produce a great approach to style the time details involving arranging constraints. When IT2FS are the unique instance involving normal type-2 FSs, here are their definition.

(iv) Interval Type-2 Fuzzy sets [4], [38-39]: An interval type-2 fuzzy set, denoted by \( \tilde{\mu}_r(x,u) \) is a special case of type-2 fuzzy set where secondary membership functions is 1 all over the primary domain i.e.

\[ \hat{T}_1 = \int_{x \in X} \int_{u \in [0,1]} 1/(x,u) \ldots \ldots \ldots \ldots (4) \]

could also state as:

We now have displayed timeline and producing amount of the duties by way of trapezoidal span type-2 fuzzy numbers. A new trapezoidal Period of time type-2 fuzzy account operate is usually displayed around Fig 1. Since demonstrated inside the Fig 1, your size of uncertainty (FOU) connected with a span type-2 Unclear establish based (IT2FS) could be the partnership of the embedded type-1 fuzzy sets. A size of uncertainty is usually bounded by way of reduced account operate (LMF) plus the Top account operate (UMF), denoted by \( u_{LMF} \) and \( u_{UMF} \). Most of us purchase trapezoidal fuzzy established for the LMF and UMF of level 1. In case the counsel of LMF(x) and UMF(x) are generally \( a \) and \( a \) respectively, then this account purpose of IT2FLS can end up being displayed as:

\[ \tilde{\mu}_r(x) = \begin{cases} \frac{x-a}{a-a} a & \leq x \leq a \\ \delta & a \leq x \leq a \end{cases} \ldots \ldots \ldots \ldots (5) \]

\[ \tilde{\mu}_r(x) = \begin{cases} \frac{x-a}{a-a} a & \leq x \leq a \\ \delta & a \leq x \leq a \end{cases} \ldots \ldots \ldots \ldots (6) \]

Most of us will usually get a couple of affiliated member's program value for each point about x-axis within the plethora of \( \mu(x) \leq 1 \), that is symbolized seeing that \( u_r(x) = [u_1, u_2] \) when shown from the Fig. 1. Your problem formulation requires the highly detailed time variables to get in contrast to a type-1 fuzzy numbers and type-2 fuzzy numbers. These types of wooly numbers are used from the formulation of one's energy efficient objective functions.

Algorithm 2:

FT2bFS (Fuzzy Type – 2 based Task Scheduling) 
Input: Crisp timing constraints \( < d_1, d_2, d_3, \ldots d_n > \) of the task \( T_i \)’s
Output: Type – reduced timing constraints
\( < d_1, d_2, d_3, \ldots d_n > \)
Method FT2bFS (x)

\[ \{ \begin{array}{l}
\text{Step 1: } \forall x \in X \text{ apply Fuzzifier } (x) = \\
\text{ } \Rightarrow \text{ Fuzzy Type – 2 Input Sets } (A)
\end{array} \]

Where \( A = \{(x,u), \mu_r(x,u) \} \forall x \in X, \forall u \in f_x \leq [0,1] \) and \( \mu_r(x) \leq u_{LMF}(x) \).

Step 2: Use Algorithm 2 and Algorithm 3 for type – reduced

type – 1 values as \( [y_1, y_2] \) for each \( d_i \).

Step 3: Get the average of type – reduced values =

\( \Rightarrow \text{ Crisp Output } (x \in d_n) \)

Step 4: Sort \( x, \) to get Schedule \( S \) and compute the completion times

Step 5: CalculateTotal \( E_i = d_i - c_i \) Earliness

Step 6: Rank \( E_i \) to check the optimality of the Earliness

4. PERFORMANCE ANALYSIS

The proposed algorithm is tested on various stages. The algorithm is applied using various performance indices like Entropy, End to end delay, Throughput, Packets drop rate. Table 1 is usually displaying your quantized research into the end to end delay They have clearly demonstrated the fact that steady period is usually highest possible in the matter of your planned algorithm as a result algorithm can
give far better success in comparison with the available methods.

**TABLE 1: END TO END DELAY**

<table>
<thead>
<tr>
<th>ITERATION</th>
<th>EXISTING</th>
<th>PROPOSED</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6.9020</td>
<td>4.1658</td>
</tr>
<tr>
<td>2</td>
<td>4.8473</td>
<td>3.1680</td>
</tr>
<tr>
<td>3</td>
<td>5.8420</td>
<td>4.1711</td>
</tr>
<tr>
<td>4</td>
<td>4.9596</td>
<td>3.1747</td>
</tr>
<tr>
<td>5</td>
<td>6.8733</td>
<td>3.1642</td>
</tr>
<tr>
<td>6</td>
<td>4.7936</td>
<td>4.1615</td>
</tr>
<tr>
<td>7</td>
<td>4.9138</td>
<td>3.1620</td>
</tr>
<tr>
<td>8</td>
<td>5.8233</td>
<td>3.1736</td>
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<tr>
<td>9</td>
<td>6.9031</td>
<td>3.1793</td>
</tr>
<tr>
<td>10</td>
<td>7.8411</td>
<td>4.1637</td>
</tr>
</tbody>
</table>

Table 2 is usually displaying your quantized research into the end to end delay. They have clearly demonstrated the fact that steady period is usually highest possible in the matter of your planned algorithm as a result algorithm can give far better success in comparison with the available methods.

**TABLE 2: PACKET DROP RATIO**

<table>
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<td>2</td>
<td>0.2432</td>
<td>0.1891</td>
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<td>3</td>
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</tr>
<tr>
<td>10</td>
<td>0.2532</td>
<td>0.1993</td>
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</tbody>
</table>

Table 3 is usually displaying your quantized research into the packet drop ratio. They have clearly demonstrated the fact that steady period is usually highest possible in the matter of your planned algorithm as a result algorithm can give far better success in comparison with the available methods.

**TABLE 3: THROUGHPUT ANALYSIS**

<table>
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</tr>
<tr>
<td>2</td>
<td>4.9488</td>
<td>6.5834</td>
</tr>
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</table>

3 | 3.9568 | 5.5782 |
4 | 4.9519 | 6.7446 |
5 | 3.9733 | 5.5963 |
6 | 4.9641 | 6.5476 |
7 | 3.9715 | 5.6935 |
8 | 4.9617 | 6.5793 |
9 | 3.9492 | 6.6750 |
10 | 4.9567 | 5.5766 |

Table 4 is usually displaying your quantized research into the waiting time. They have clearly demonstrated the fact that steady period is usually highest possible in the matter of your planned algorithm as a result algorithm can give far better success in comparison with the available methods.

**TABLE 4: WAITING TIME**

<table>
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</tr>
<tr>
<td>10</td>
<td>6.2524</td>
<td>4.2692</td>
</tr>
</tbody>
</table>

5. CONCLUSION

A new generation referred to as Radio Frequency Identification (RFID) is added which may be combined with the existing signaling machine. It can act as a key to smart visitors control in real-time. This new generation with a view to require much less time for set up with lesser prices as compared to different techniques of site traffic congestion management. However, it suffers from the uncertainty issue. Therefore, in this paper a novel, Type-II fuzzy based congestion control system is proposed to control urban traffic. Extensive experiments reveal that the proposed technique outperforms the existing technique.

6 REFERENCES

Signals of Urban Corridor. CISTUP - International Conference, IISC – Bangalore, Karnataka State, India. (18-20 Oct, 2010).


