IRAQI Academic Scientific Journals

Al-Kut University College Journal

ISSN (E) : 2616 - 7808 II ISSN (P) : 2414 - 7419
www.kutcollegejournal.alkutcollege.edu.iq
k.u.c.j.sci@alkutcollege.edu.iq

Special Issue for the Researches of the 5th Int. Sci. Conf. for Creativity for 13-14 December 2023

Simulating Traffic U-Turns Intersection in the VISSIM Program and the Behavior of Accepting or Rejecting the Gap: A Case Study of the City of Najaf

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Abstract

Generally, at the crossroads, there is a lot of traffic jam, and during rush hour, there are many accidents. Because of the impact of U-turn intersections on how the road network operates and the characteristics of traffic, such as delay times and queues, the examination of U-turn intersections is primarily a traffic engineering effort. It is caused by the accumulation of moving vehicles and the congestion caused by the many accidents that occur in specific places. Delays and accidents are affected by many different factors. Drivers' movements (driving behaviors) and age Features of vehicles, the aggression of enemy vehicles, and their speed as traffic congestion increased, I was more likely to be able to turn. Three locations of opposite intersections in Najaf, which is 160 kilometers (about 100 miles) south of Baghdad, are the subject of the current study. Based on the acceptance or rejection of gaps, delays, and driving habits that may lead to many accidents, delays, and traffic congestion, and studying and simulating traffic volumes using the VISSIM program, the study relied on analyzing the operational performance of intersections. According to the results, the critical gaps were 3.5, 4, and 4.2 seconds, and the follow-up times were 3, 3.1, and 3.5 seconds, respectively. Studies of reversing intersections demonstrate the importance of these intersections for both traffic flow and safety.

Keywords: Gap, Follow-Up, Critical Gap

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Paper Info.
Published: June 2024

محاكاه تقاطع المنعطفات المرورية في برنامج VISSIMوسلوك قبول او رفض الفجوة دراسة حاله في مدينه النجف الاشرف

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المستخلص

بشكل عام، عند مفترق الطرق، هناك الكثير من الازدحام المروري، وخلال ساعة الذروة هناك العديد من الحوادث. نظرًا لتأثير التقاطعات ذات الدوران على شكل حرف U على كيفية عمل شبكة الطرق وخصائص حركة المرور، مثل أوقات التأخير وطوابير الانتظار، فإن فحص التقاطعات ذات الدوران على شكل حرف U هو في المقام الأول جهد هندسي مروري. ويعود سببه إلى تكدس المركبات المتحركة والازدحام الناتج عن كثرة الحوادث التي تحدث في أماكن محددة. تتأثر التأخيرات والحوادث بالعديد من العوامل المختلفة. حركات السائقين (سلوكيات القيادة) والعمر. ميزات المركبات وعدوانية مركبات العدو وسرعتها مع زيادة الازدحام المروري، كان من المرجح أن أتمكن من الانعطاف. ثلاثة مواقع لتقاطعات متقابلة في مدينة النجف التي تبعد 160 كيلومترا (حوالي 100 ميل) جنوب بغداد هي موضوع الدراسة الحالية. بناءً على قبول أو رفض الفجوات والتأخيرات وعادات القيادة التي قد تؤدي إلى العديد من الحوادث والتأخيرات والازدحامات المرورية، ودراسة ومحاكاة الأحجام المرورية باستخدام برنامج فيسيم، اعتمدت الدراسة على تحليل الأداء التشغيلي للتقاطعات. ووفقا للنتائج، كانت الفجوات الحرجة 3.5، 4، و 4.2 ثانية، وكانت أوقات المتابعة 3، 3.1، و 3.5 ثانية، على التوالي. توضح دراسات التقاطعات العكسية أهمية هذه التقاطعات لكل من تدفق حركة المرور والسلامة.

الكلمات المفتاحية: الفجوة، المتابعة، الفجوات الحرجة

انتساب الباحثين

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معلومات البحث
تاريخ النشر: حزيران 2024

Introduction

Any industrialized nation's highway system makes up a segment of its transportation system in addition to the conventional modes of transportation that have advanced over many years. A highway system is made up of many different parts, such as vehicles, paving, parking spaces, and controller software. All of these components function by the specified guidelines and schedules for air, land, and sea transportation. A driver searches for a place where it is safe to cross when approaching an un signalized intersection. The driver decides whether to accept or reject the gaps that are there based on the planned circumstances and the opposite direction [1]. The "critical gap" is the smallest window of time in the main traffic flow that allows a vehicle in the sub-flow to get to an intersection. Crossings are always in use by the perfect global law of traffic flow [2]. The gap is the separation between the front bumper of the first car and the starting point of the second. The distance between two cars, in meters (m), is calculated over a certain amount of time from one car's back bumper to the other's front bumper. (seconds) (2010 Guide) A vehicle can only enter a junction safely in a small flow, however, if there is enough of a gap (i.e., a distance that permits entry into the conflict) [3].You must decide whether to cross over into the open area. The decision to accept a gap may be influenced by a variety of factors, including traffic, geometric, environmental, and human ones. The likelihood of a competing vehicle on the main road, as well as its speed, range, and weight, all influence whether it is safe to cross [4].Numerous studies have also been conducted to create simulation models for the U-turn portion. As [5]. points out. The investigation and analysis of geometric design permitting right turn and U-turn movements on urban or suburban multilane highways focused on weaving motions and delay times. A comprehensive list of factors influencing crucial gap periods and follow-up time values is presented [6].

[7] combined the conventional method with two different approaches to determine the crucial distance for the U-turn movement in India. Raff's conduct and manner were modified. They concluded that motorcycle riders accepted a narrower distance than those operating other types of vehicles. The low percentage of HVs in the study area was not taken into account. The questioned vehicle type [8]. Examined how motorists acted at intersections without traffic signals. To investigate how drivers who accept gaps behave, a four-legged, uncontrolled intersection in Ahmadabad was used. The critical gap was calculated using a variety of methods. Three distinct chasms, three distinct types [9]. used field data collected at 14 two-way junctions in Shanghai, China, to evaluate stop behavior and the critical gap. The approved gaps are used to establish the crucial gaps and gaps that were excluded using the Raff and greatest likelihood techniques. This analysis's calculated values have been contrasted with the values suggested by HCM in 2010. The writers were unable to locate a significant correlation between the stop time and the allowed gaps for tiny movements. Additionally, it was discovered that Shanghai's crucial gaps are smaller than in other nations (such as the United States, on average). 19.0 percent on average with the same number of lanes) [10]. used Raff, MLM, macroscopic probability equilibrium, merging behavior, and other methods to estimate

the critical gap for the U-turn movement at seven median openings in India for heterogeneous traffic. They also examined how people's acceptance of gaps varied depending on the kind of vehicle. The results showed that motorcycle drivers accepted a smaller distance than those of other vehicles. Since there were so few observations in their investigation, HVs were not examined. The subject vehicle (which is making a U-turn) may reject a few minor gaps (often smaller than important gaps) as a result of evaluating the gaps in the opposing through traffic, which will delay the operation. These middle apertures, however, actually operate pretty sloppily. in consideration of the priority of the laws governing mobility and what [11]. The critical separation from these openings is estimated by [12]. The recently developed 'INAFOGA' technique, which is based on the clearing behavior of vehicles at non-signalized intersections, is modified and put into practice by taking into consideration the merging behavior of U-turn vehicles at median openings. In addition to a vehicle's gap-accepting features, it also considers its actual merging behavior. The research revealed that the results were intermediate when compared to those estimated using traditional methods and inferior to those in HCM. The most crucial component in establishing the opening capacity for U-turns is gap acceptance. Drivers' perspectives on tolerating gaps have an impact on the safety and effectiveness of U-turns. To complete the U-turn phase safely, the driver needs sufficient space. This study tests a statistical model that forecasts driver gap acceptance behavior. [13] have documented traffic volumes and features such as vehicle types, opposing through traffic, turning actions, permitted headways, wait periods, and the number of lanes in each direction. Additionally, motorists are more cautious because they frequently drive their cars, as opposed to trained drivers of HVs, who frequently convey goods and people. As a result, motorists are more likely to drive defensively and safely [14]. used simulation and empirical methodologies to calculate the capacity of U-turn movement at divided arterial median openings. As shown in Figure (1). A representation of a U-turn according to [15]. Study area as shown in Figure (2).

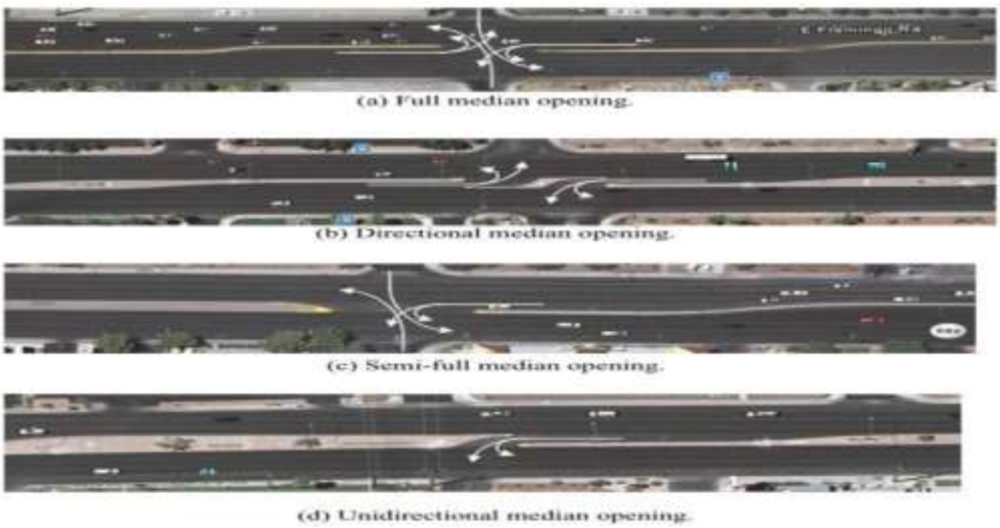

Figure (1): Types of median apertures [15]

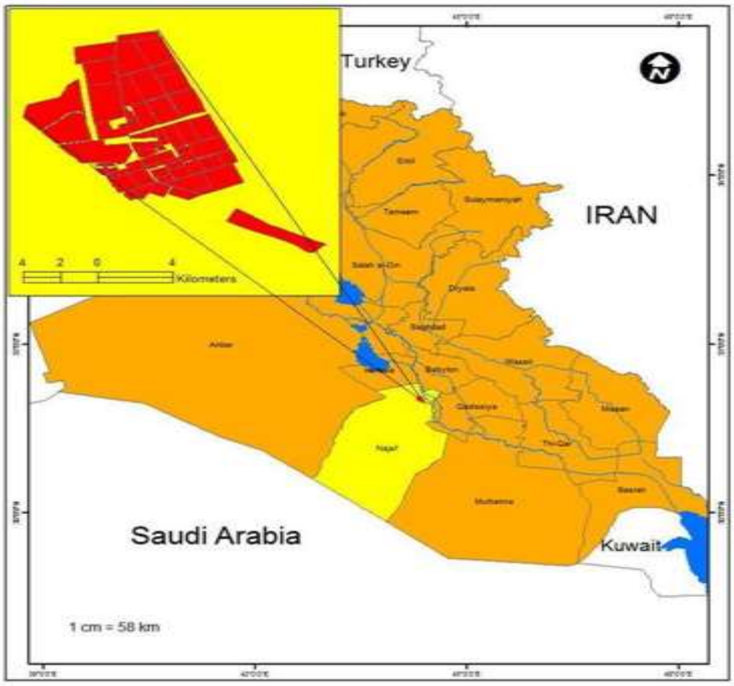

Figure (2): Site of the city of Najaf, Iraq

2. The websites chosen or data collection

Three sites in the city of Najaf were chosen by the type of roads being studied and the purpose of our study. These sites are shown in the figure (3).

1. Kufa-Najaf street
2. Al-Mattar street
3. Ghadeer-Furat street

3. Methodology

3.1. Site selection and specifications

To determine the appropriate locations for the U-turn intersections and to identify the highway sections, a brief survey trip was made over the research area. To obtain sufficient data, the locations must also provide a suitable environment for mounting video cameras. It was crucial to pay attention to the volume of traffic. The research locations are found in an urban area distinguished by its profusion of shops, offices, and other businesses. Carefully selected imaging sites allowed for the observation of compound counts and movements. To identify the highway sections, a brief survey trip was conducted around the study zone to determine the locations of the U-turn intersections. To collect adequate data, the venues must also provide a suitable environment for installing video cameras. Observing the volume of traffic was crucial. The study sites are located in an urban area known for having a large number of shops, offices, and other commercial establishments. Care was taken in selecting the imaging locations such that compound counts and motions could be observed. Important intersections were chosen in the holy city of Najaf, as shown in Figure (3) , which are located on an important streets, and the functional category of the streets was determined according to HCM 2000.
as shown in Table (1).

Figure (3): U-turn study sites that have been chosen

Table (1) : Functional Class for the selected streets according to HCM 2000

Site	Street	Functional class
1	Kufa-Najaf street	Major arterial
2	street Al-Mattar	Major arterial
3	Ghadeer-Furat street	minor arterial

1 - U-turn Kufa-Najaf street

In the city of Najaf, this is one of the busiest back-to-back turns. It is situated across from the University of Kufa's main gate on the Kufa-Najaf road. It is one of the crossroads where traffic bottlenecks and congestion are common. This is explained by the fact that the majority of flights originate in the Najaf direction (i.e., 70% of all flights arrive at the University of Kufa).

2 - U-turn Al-Mattar street

This intersection is located on Al-Mattar Street, which is one of the most important streets in the city of Najaf. The street is divided into three lanes in each direction, and the traffic volumes are high at this intersection because it connects vital areas as it passes through Najaf International Airport and continues to Najaf-Karbala Street.

3 - U-turn Ghadeer-Furat street

This intersection is also one of the most important intersections because it is located in an area that contains many important government departments, which causes an increase in the volume of traffic passing through it. Compound were classified in a U-shape for all sites as shown in Table (2). The movements of the studied vehicles were divided into merge 1 volume, merge

2 volume, through volume, opposing volume as shown in Figure (4).

Table 2: Classification of vehicles U-turn for all sites

No. U-turn	% PC	%Truck	% Bus	% 2-wheel veh	% 3-wheel veh	% Mini-Bus
U1	82	2.2	2	2	2	9.8
U2	85	4.2	1	1.6	1.4	6.7
U3	86	0.8	1.4	2.1	2.1	7.6

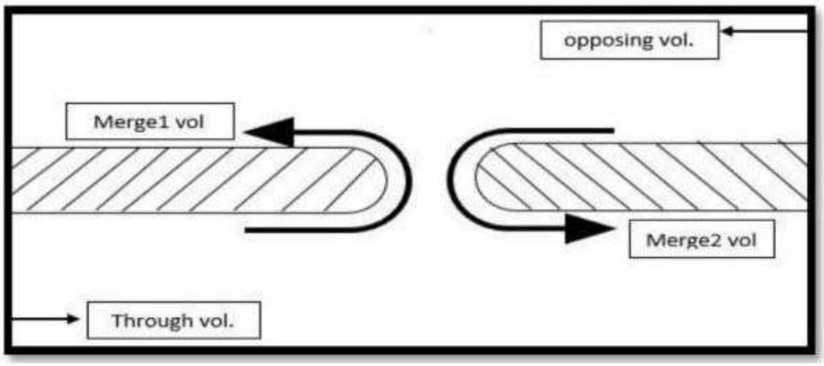

Figure (4).: shows the design of U-turn locations along with the traffic volume label

3.2. The behavior of accepting or rejecting the gap

Based on the gap acceptance behavior, a U-turn movement at an un signalized midblock median opening is made. When a car approaches a median opening, the driver must face the gaps of the opposing throughways. waits for a suitable space in the traffic before making a U-turn. The U-turn maneuver is intricate and may raise questions about safety. A gap is typically thought of as the space between two successively moving vehicles in a traffic lane. The lowest amount of time required for main street traffic to move is known as the crucial gap (HCM 2010).

4. Data analysis and results

The highway section area imaged within 50 m before and after the three selected sites began to be recorded for two to one and a half hours. The results of following up the traffic volumes are presented and simulated with the VISSIM program, and the results are compared, as well as 100 cases of acceptable gaps and the corresponding rejected gaps, the waiting time and the flow up for each gap length, and the extraction of the critical gap by the Raff's method were studied. The values of the accepted and rejected gaps, the time of delays, the follow-up time, and the value of the critical gap for the first site, as shown in Table (3). And shown in Figure (5).

Table (3): Data for U-turn 1 for 100 vehicles accepted gap

Gap length.sec	No.Accepted	No.Rejected	% Accepted	%Rejected	Waiting Time. sec	Follow up. sec
1	0	116	0	26.4	0	0
2	10	117	10	26.6	9	2.5
3	10	66	10	15	10.1	3.1
4	16	48	16	10.7	9.5	1.8
5	12	49	12	11	9.6	3.7
6	10	26	10	5.9	6	3.1
7	9	13	9	3	7.3	2.3
8	8	9	8	2	6.5	2.8
9	13	4	13	0.8	11.8	4.5
10	12	0	12	0	4.3	3
	100=T	**448=T**			**8.2=Avg.**	**3=Avg.**

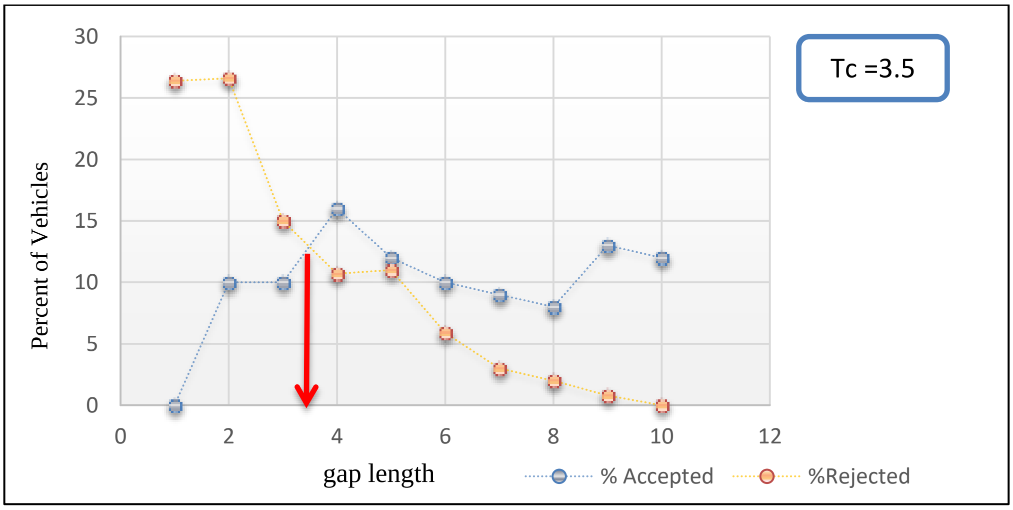

Figure (5) Gap Diagram U-turn 1

The percentage of drivers who complete a turn with a time greater than the critical time gap 20%

The percentage of reckless drivers who complete a turn with a time less than the critical Time is 80 % in U-turn 1.

The values of the accepted and rejected gaps, the time of delays, the follow-up time, and the value of the critical gap for the second site, as shown in Table (4). And shown in Figure (6).

Table (4) Data for U-turn 2 for 100 vehicles accepted gap

Gap length. sec	No.Accepted	No.Rejected	% Accepted	% Rejected	Waiting Time. sec	Follow up. sec.
1	0	73	0	21.2	0	0
2	15	80	15	23.3	10.2	2.8
3	10	77	10	22.4	8	3.3
4	9	30	9	8.7	7	2.9
5	12	41	12	11.7	6.5	4.3
6	10	21	10	6.1	5.1	3.6
7	9	7	9	2.1	6.7	2.5
8	8	10	8	3	5.1	2.7
9	12	0	12	0	5.4	1.9
10	15	5	15	1.5	4.9	3.7
	T =100	T= 344			Avg. = 6.6	Avg. = 3.1

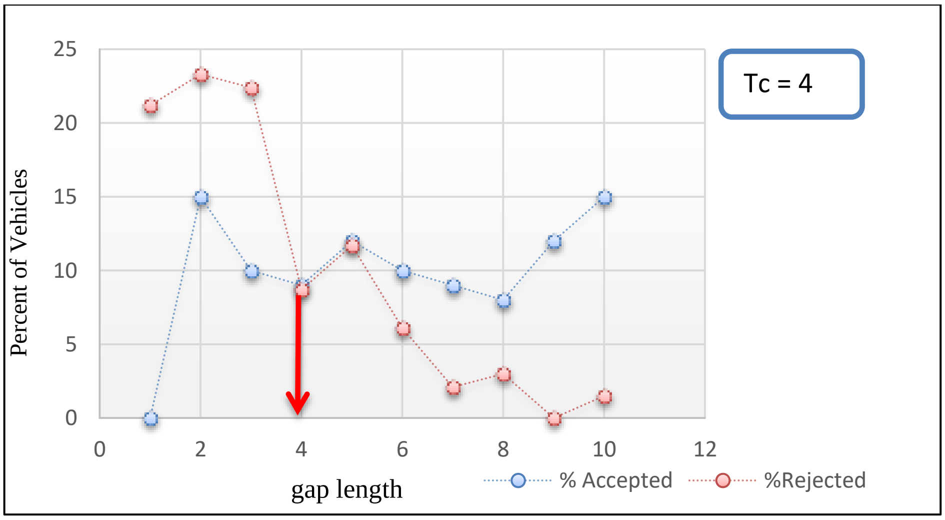

Figure (6): Gap Diagram u turn 2

The percentage of drivers who complete a turn with a time greater than the critical time gap is 34%. The percentage of reckless drivers who complete a turn with a time less than the critical Time is 66 % in U-turn 2.

The values of the accepted and rejected gaps, the time of delays, the follow-up time, and the value of the critical gap for the third site. as shown in Table (5). And shown in Figure (7).

Table (5): Data for U-turn 3 for 100 vehicles accepted gap

Gap length. sec	Accepte. No d	No.Rejected	Accepted %	% Rejected	Waiting Time. sec	Follow up. sec
1	0	89	0	22.9	0	0
2	9	89	9	23	8.1	4.3
3	10	66	10	17	6.9	2.7
4	15	62	15	16	7.2	4.1
5	13	43	13	11	8.5	2.9
6	11	12	11	3.1	5.7	4.1
7	9	7	9	1.9	4.8	3.6
8	8	16	8	4	5.2	3.3
9	11	3	11	0.7	4.1	4.3
10	14	2	14	0.5	4	1.9
	T =100	**T =389**			**Avg. = 6.1**	**Avg. = 3.5**

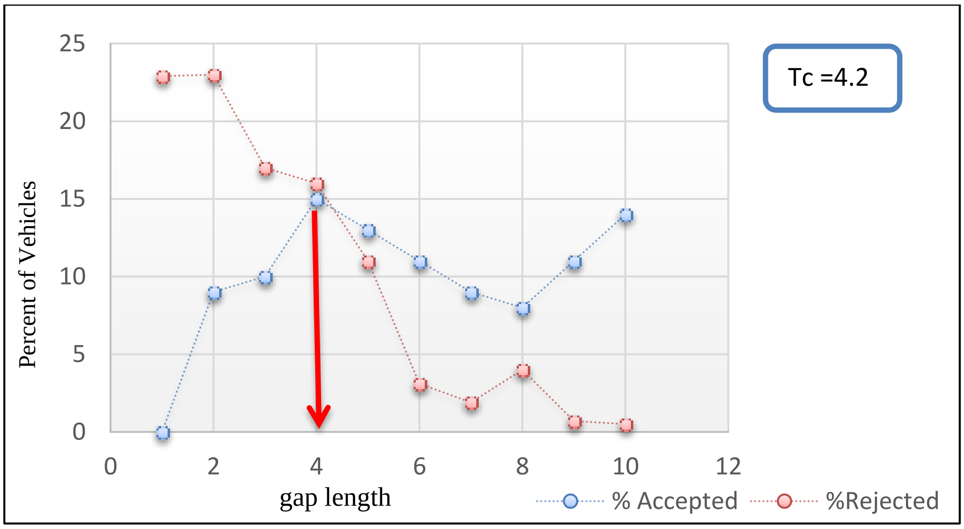

Figure (7): Gap Diagram u turn 3

The percentage of drivers who complete a turn with a time greater than the critical time gap is 19%. The percentage of reckless drivers who complete a turn with a time less than the critical Time is 81% in U-turn 3.

5. Simulation models

The development of the simulation model, process calibration, and validation are all included in this part. The maximum simulation time for a student's license using VISSIM software is 5 minutes, during which the readings were taken for 5 minutes and the average difference was extracted for 15 minutes. Based on the available information, it was calculated to take 1.5 hours for the first and second sites and 2 hours for the third site. Developing models for the studied sites, using the VISSIM program, traffic networks were generated that can be compared to those in the real sites. To build VISSIM models, connections (used for road drawing) and connections (used for drawing Use Yield Priority to make the turning vehicle wait until there is enough room to turn before doing so. hill Speed Zone Reduction is used to limit the speed. The amount of movement in each direction is recorded using the Vehicle Entry Tool. Enter the priorities of these movements A "conflict zone" where opposing traffic is given priority. Simulation model development, process calibration, and verification are included in this part. The maximum simulation time for Student License using VISSIM software is 5 minutes, during which 5-minute readings were taken and a 15-minute mean difference was extracted. Based on the available information, it was calculated that it would take 1.5 hours for the first and second sites and 2 hours for the third site. Developing models for the studied sites using the VISSIM program. Traffic networks were created that can be compared with those in real sites. For building VISSIM models, connections (used for route drawing) and connections (used for drawing) Use the turn priority to make the turning vehicle wait until there is enough room to turn before doing so. hill Speed reduction is used to determine the speed. The amount of movement in each direction is recorded using the vehicle entry tool. Enter the priorities of these movements A "conflict zone" where opposing traffic is given priority. The program interface and structure are explained in the VISSIM program window VISSIM modeling builds a snapshot as shown in Figure (8) and Figure (9).

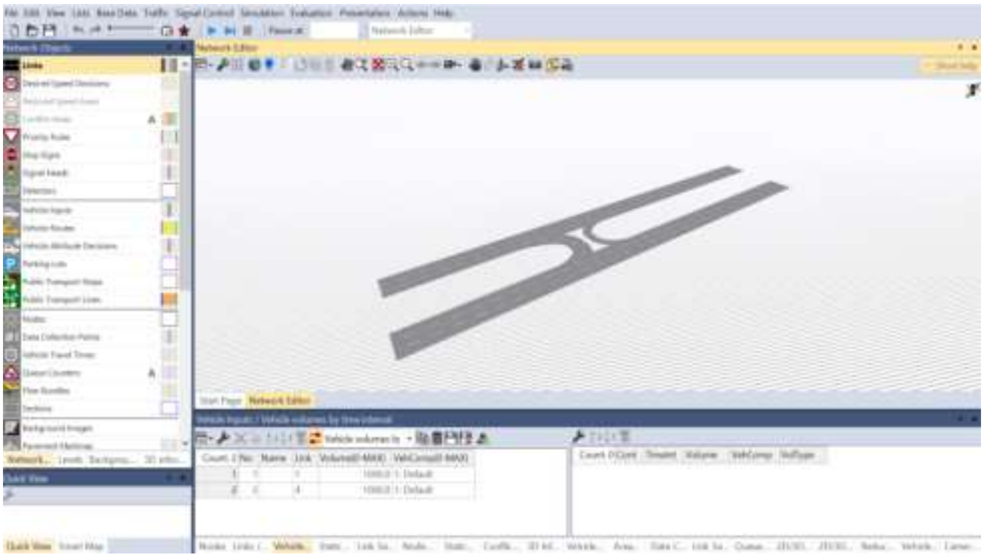

Figure (8): VISSIM program window

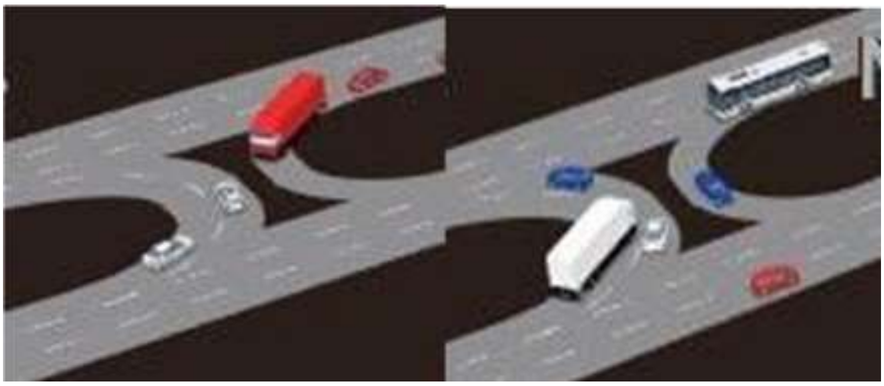

Figure (9): VISSIM modeling builds a snapshot

6. Statistical test

For the calibration and validation process to compare the simulation and real data, statistical tests are necessary. The GEH formula was created in the 1970s by Geoffrey E, as shown in Equation 1 below (Muhanad,2018).

$$\text{GEH} = \left[\frac{(s-0)^2}{0.5(S+0)}\right]^{½} \quad (1)$$

Where

S= simulation data

O = Observed data.

When comparing the volumes of real and simulated data, this equation is used.

- **GEH < 5:** indicates good fitness
- **5<GEH<10**: more examinations may be required
- **GEH > 10:** Poor fitness

The actual traffic volumes for all sites were extracted and simulated using the VISSIM model and the difference between them was found as shown in Tables from (6) to (8).

Table 6: The result of simulation and actual result in VISSIM for site No.1

Time	Actual merge1 vol.	Simulated merge vol.	The difference	Actual merge2 vol.	Simulated merge vol.	Avg. difference
7.30: 7.45	184	137	3.7	152	133	1.5
7.45: 8.00	267	244	1.4	134	117	**1.5**
8.00: 8.15	196	154	3.1	147	124	**1.9**
8.15: 8.30	189	147	3.2	154	137	**1.4**
8.30: 8.45	152	130	1.2	148	123	**2.1**
8.45: 9.00	147	130	1.4	137	117	**1.7**

Table(7): The result of simulation and actual result in VISSIM for site No.*2*

Time	Actual merge1 vol.	Simulated merge vol.	The difference	Actual merge2 vol.	Simulated merge vol.	Avg difference
7.30: 7.45	378	321	3	126	363	2.1
7.45: 8.00	371	292	4.3	119	401	1.9
8.00: 8.15	353	300	2.9	141	386	2.2
8.15: 8.30	417	331	4.4	147	371	2
8.30: 8.45	390	332	3	135	326	1.6
8.45: 9.00	378	296	4.4	132	401	2.1

Table 8: The result of simulation and actual result in VISSIM for site No 3

Time	Actual merge1 vol.	Simulated merge vol.	The difference	Actual merge2 vol.	Simulated merge vol.	Avg. difference
7.00: 7.15	29	37	1.3	57	54	0.4
7.15: 7.30	59	65	0.7	49	39	1.5
7.30: 7.45	117	93	2.3	45	39	0.9
7.45: 8.00	65	54	1.4	45	37	1.2
8.00: 8.15	61	50	1.4	60	50	1.3
8.15: 8.30	53	41	1.7	40	32	1.3
8.30: 8.45	47	39	1.2	42	34	1.2
8.45: 9.00	44	37	1	45	38	1

Conclusions

U-turn intersections U1, U2, and U3 have average follow-up times of 3, 3.1, and 3.5 seconds, respectively, based on 500 computed follow-ups, according to data obtained from field score calculations and gap length calculations. From the calculations, the field results indicate that the critical gaps for the studied segment are 3.5, 4, and 4.2 s, and the values of the critical gap and follow-up time are affected by the conflicting volume, traffic volume, conflicting travel speed, delay time, and queue length, which regulate the rotational amplitude U(c).) [10]: C = 3600 / (c.g + f.u) (1) where c.g. is the duration of the main gap and f. It's time to follow up. The UI, U2, and U-turn have capacities of 554, 508, and 468 cars per hour, respectively. The VISSIM micro-simulation tool was used in this study to simulate the traffic movements at specific bypass locations in the Iraqi city of Najaf. Real-time traffic data was collected from a given location using video capture to predict necessary characteristics, such as merging and alternation between desired and opposing traffic volumes and turning lanes. The maximum flow at the first site was 1068 for the highest volume at 7.45:8.00, the second site was 1668 for the highest volume at 8.15:8.30, and the third site was 468 for the highest volume at 7.30:7.45. Using actual site data, simulation models were calibrated and validated. Subject to merging and opposition through magnitude and median. For comparison. A strong consensus was reached, demonstrating the capability of VISSIM. Real traffic simulation for such complex websites After model calibration and validation stages, statistical testing provides acceptable agreement. So the models produced can be used for more applications in different test scenarios when using real data. scenarios.

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