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Improving Walkability of People with Reduced Mobility at An Intersection Using Microsimulation In VISSIM And SSAM

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Abstract **-** In this research project, the evaluation of the accessibility and mobility difficulties faced by people with disabilities when circulating around a vehicular intersection is addressed. To carry out this evaluation, the Vissim and SSAM programs were used. The assessment of conflicts is carried out through the analysis of heat maps obtained with SSAM. In the context of this article, an analysis is carried out of the number of conflicts between vehicles on a road segment that is part of a traffic signalized intersection, characterized by the constant presence of congestion. Along this stretch, a decrease in lanes, variability in lane widths and lack of uniformity are observed, generating a point of congestion that gives rise to various types of vehicular conflicts. To carry out this evaluation, the micro simulation software VISSIM 8.0 was used, which models the real situation of the intersection. Two new scenarios are proposed, in which suggestions for geometric redesign are introduced in the infrastructure of the road section with the objective of analyzing the influence on the variability of the number of vehicular conflicts. The proposedmethodology consists of three fundamental stages: (i) obtaining the passage times of four types of vehicles that circulate in the area and the passagetimes of people with disabilities along the track, (ii) the modeling in the Vissim program and (iii) the implementation of the proposed improvements.

Keywords**:** reduced mobility, disability, accessibility, pedestrian, vissim, SSAM, urban mobility

1. Introduction

There are studies that focus on road safety and the incidence of vehicular conflicts at intersections through the use of micro simulation and SSAM, marking significant milestones. In a specific investigation, a safety evaluation was carried out at signalized intersections, using a micro simulation model developed in VISSIM. Through the use of the Surrogate Safety Model (SSAM), vehicular conflicts were classified according to their severity in relation to the collision time (TTC), allowing the identification of the critical points with the highest concentration of conflicts [1]. Furthermore, the study demonstrates the application of a micro simulation environment to predict conflicts between vehicles at signalized intersections. The lack of accessibility on the streets for people with reduced mobility is a challenging problem for anyone who has a disability, whether due to an injury, a visual problem or due to age. In Peru, specifically in Lima, many busy streets are not designed for pedestrian crossing, which harms the common pedestrian. In this situation, the most affected among all pedestrians are people with reduced mobility, since they put their health at risk when traveling on these unsafe roads, in turn, they lose autonomy and independence, since they would need to have the presence of a third person to be able to transit. Today, there are many ways to solve these problems, such as the creation of new technologies in the field of urban transportation. In [2] they used the VISSIM and SSAM software to estimate traffic conflicts through field measurements in highway junction areas. Conflicts in the field were collected manually and compared with simulated conflicts. The results showed a sensitive coherence between the observed and simulated conflicts. The current article, titled "The Impact of Waiting Time and Other Factors on Dangerous Pedestrian Crossings and Violations at Signalized Intersections: A Case Study in Montreal", focuses on analyzing the behavior of pedestrians when crossing signalized intersections. This study considers various characteristics, such as gender, age, and road conditions, among other factors, particularly in people commuting to work or school. [3] It has been observed that those who travel urgently are more likely to commit violations.

Improving the capacity and standardization of roads to improve road safety is an important task in a constantly growing city like Lima, Peru, where due to uncontrolled urban growth, deficiencies in road infrastructure and traffic administration originated. which, added to the lack of urban planning, worsened over the years [4]. Its origin is in the lack of planning and urban coordination between the different municipalities of the city, resulting in the roads being designed according to the criteria of each district in an almost independent and non-cooperative manner while fighting with the exponentialgrowth of the population. urban. [5]

The TTC, being the most commonly used indicator, is also the choice in this study to evaluate the severity of conflicts.

Originally proposed by Hayward in 1972, TTC is defined as the "travel time until a collision occurs between vehicles ifthey continue on their current course at their current speeds" [6]. In this context, traffic conflicts are evaluated consideringa TTC threshold of 1.5 seconds, where higher values indicate a lower severity of vehicular conflicts.

2. Methodology

In this research, the comparative analysis of the data obtained in the field and the data obtained from the Vissim and SSAM programs is developed. In the first stage, the description and data collection of the study area is carried out, and the current state of the sidewalks, traffic lights and state of the ramps according to standard A.120. In the second stage, the intersection is modeled in the VISSIM program and the records used are processed. The third stage involves data collection and modeling analysis in the VISSIM and SSAM software. This analysis consists of the calibration and validation of the data obtained in the field and the data obtained by the Vissim and SSAM programs. It should be noted that 15 runs of the Vissim program were carried out to obtain the data that were used for comparison with the field data.

Once it has been verified that the times in the modeling coincide with the times of the real situation, the fourth stage begins, which is the modeling of the redesign of the study area and readjustment of the traffic light cycle. After that, the fifth stage begins, which is the implementation of the SSAM and, finally, the sixth stage consists of the analysis of the number of conflicts obtained in SSAM of the current situation and the solution proposal.

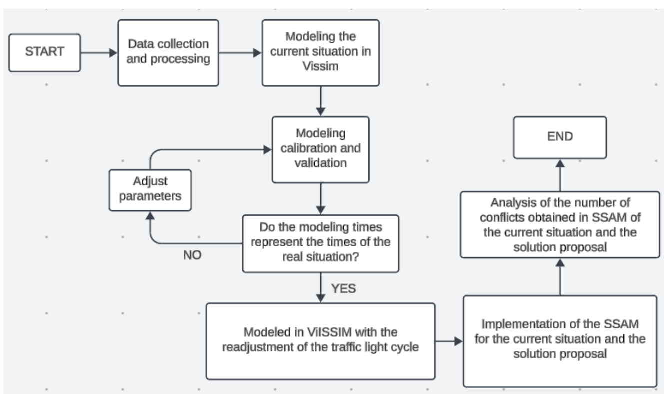

Fig. 1: Flowchart of steps to follow

3. Equations

This section focuses on the precise formal representation of the key elements related to improving the walkability of people with reduced mobility at an intersection, using micro simulation in VISSIM and SSAM. That is why, for this case, a number of runs were carried out in a certain time, which was 1 hour.

Run analysis in 1 hour:

Confidence is established at 95% and the significance level is α=0.05:

$$\frac{\alpha}{2} = 0.025 \quad (1)$$

To calculate the number of runs, the following operation is calculated:

$$N_{min} = \left(\frac{1.997*13.16}{0.068}\right)^2 = 15\ runs \quad (2)$$

4. Tools

For this case, the use of Vissim software was implemented in which the following input data needed to be entered.

Input data:

- Approximate percentage of people passing through the intersection.
- Travel time of vehicles passing through the study area.
- Traffic light timing.

Through the visit to the study area, the vehicular and pedestrian capacity at the intersection of Túpac Amaru Avenue and Revolution Avenue was obtained.

4.1. Vehicle and pedestrian capacity

A total of 2,700 vehicles were obtained as total vehicle capacity between 5:00 p.m. and 8:00 p.m., as shown in the following Table 1:

Table 1: Vehicle capacity according to mode of transport

TYPE OF TRANSPORT	NORTH - SOUTH				SOUTH - NORTH				EAST - NORTH				EAST - SOUTH				TOTAL	%
	1A3	1A2A	1A1	1A1	2A1	2A2A	2A3	2A3	31A	31	32	32	41A	41A	41	42		
MOTORCYCLE	4	23	8	1	1	26	6	1	0	5	5	1	1	8	3	0	93	3,44%
MOTORCYCLE TAXI	1	38	10	5	22	22	3	3	2	21	60	68	9	60	13	0	337	12,48%
PRIVATE VEHICLE	17	462	203	12	120	443	74	16	127	174	149	13	42	152	49	0	2053	76,04%
PUBLIC VEHICLE	0	80	0	1	0	100	11	0	1	6	0	1	0	5	12	0	217	8,04%
																	2700	100%

The total pedestrian capacity between 5:00 p.m. and 8:00 p.m. was 344 pedestrians, as shown in the following table:

Table 2: Pedestrian movement capacity of pedestrian types

TYPE OF PERSON	NS-1	SN-1	EW-1	WE-1	EW-2	WE-2	TOTAL
YOUTHS	7	10	5	3	8	14	47
ADULTS	15	18	13	20	25	22	113
MIDDLE-AGED ADULTS	17	21	15	13	19	11	96
OLDER ADULTS	16	13	10	14	14	21	88
TOTAL	55	62	43	50	66	68	344

Of which the number of people with reduced mobility are the following:

Table 3: Capacity of pedestrian movements of the types of pedestrians evaluated

TYPE OF PERSON	NS-1	SN-1	EO-1	OE-1	EO-2	OE-2	TOTAL	%
PERSON WITH CRUTCHES	3	1	5	2	4	4	19	15%
PERSON WITH BLINDNESS	5	7	3	8	9	2	34	28%
PERSON WITH CANE	8	6	2	5	3	6	30	24%
PERSON IN A WHEELCHAIR	4	9	10	7	1	9	40	33%
TOTAL	20	23	20	22	17	21	123	

5. Calibration

The calibration was carried out for both pedestrian and vehicle. For both cases the local conditions were the same and the parameter used is the travel time. For the modeling design, the network was designed, volumes were assigned, and vehicular components were assigned.

5.1. Network Design

To define the network, the satellite view of the study area provided by the Vissim program was used. The links began to be generated respecting the road widths. Using the links, the model was designed that faithfully reflects all the types of movements that occur within it.

5.2. Vehicle Composition and Volume

In the software, the “vehicle inputs” were defined, that is, the point of the network from which the vehicles entered, with their respective attributes.

Six vehicle entry points were defined in both directions:

a. Entrance in the east-south direction from Revolution Avenue to Túpac Amaru Avenue.
b. Entrance in the east-north direction from Revolution Avenue to Túpac Amaru Avenue.
c. Entrance in the north-east direction from Túpac Amaru Avenue to Revolution Avenue.
d. Entrance in the southeast direction from Túpac Amaru Avenue to Revolution Avenue.
e. Entrance from north-south on Túpac Amaru Avenue.
f. Entrance from south-north on Túpac Amaru Avenue.

For the volume and vehicle composition of each entry, the average values were used.

5.3. Route Assignment

The different routes to follow from the access points were assigned. To do this, the starting point for route decisions was defined at the entrance of the vehicular flow. Then the starting point of each of the different options is defined, marking the route that the vehicles follow. Then, for each possible route, the percentage of the vehicular flow that arrives at the beginning was determined.

5.4. Vehicle and pedestrian Calibration

For the calibration of the vehicles, a section within the area was chosen to obtain the travel times in the study area and the software.

Table 4: Vehicular flow introduced in microsimulation

Vehicular Flow
Microbus
Buses
Taxis
Motorcycle taxi
Motorcycle

Table 5: Travel time

TRAVEL TIME (seconds)	
VISSIM	FIELD STUDY
43.26	42.5
35.8	33.9
41.2	40.8
36.12	37.2
36.2	36.9
46.3	45.5
35.21	36.1
42.14	41.7
38.4	39.8
43.07	41.9
33.33	34.2
47.6	47.3
35.06	33.8
39.4	32.5

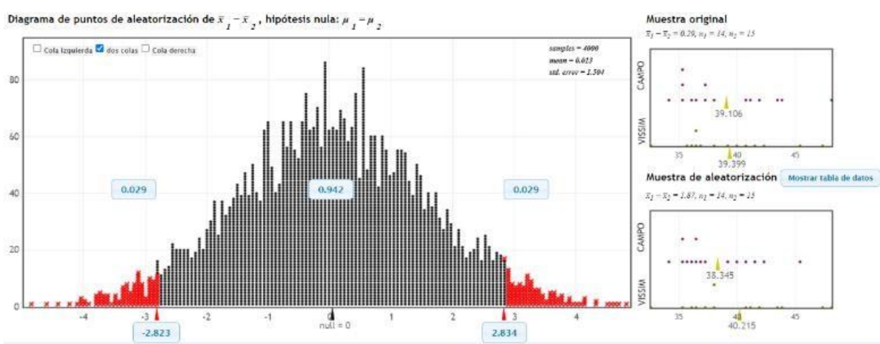

Fig. 2: Comparison table of data obtained in Vissim and in the Field.

This graph was generated using the Statkey tool to evaluate the null hypothesis of mean difference using 4000 permutations. The results indicate that the difference in means is 0.29, and this value is within the confidence limits that range between -2.823 and 2.834. Consequently, with a confidence level of 95% and a significance level of 0.05, it is concluded that the model is accepted.

The calibration parameter used for pedestrians was travel time. For this work, the travel time of 4 types of pedestrians with reduced mobility throughout the study area was measured. In total, 15 travel time samples were obtained that will be compared with the times obtained in Vissim.

Table 6: Type of reduced mobility of pedestrians

Type of reduced mobility
Person with crutches
Person with blindness
Person with cane
Person in a wheelchair

Table 7: Pedestrian travel time in seconds obtained in the field and in Viswalk

TRAVEL TIME (seconds)	
VISWALK	FIELD STUDY
58.3	57.6
49.8	51.1
53.7	48.99
52.5	60.3
58.56	59.19
49.5	50.1
52.86	51.94
54.72	53.81
60.15	59.78
52.36	53.12
49.99	51.3
54.9	55.3
52.16	53.24

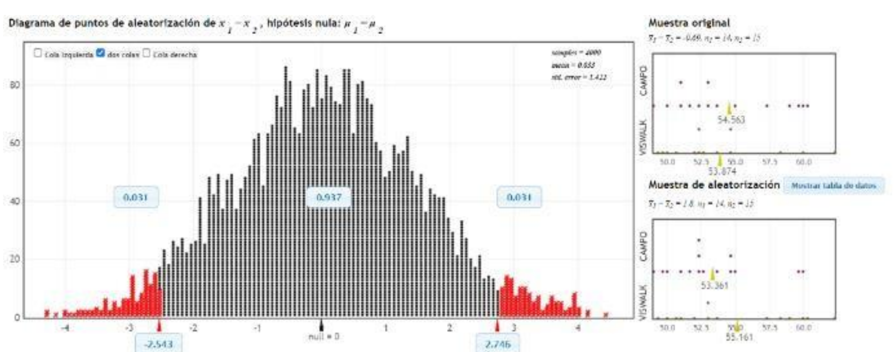

Fig. 3: Pedestrian travel time randomization dot plot

This graph was generated using the Statkey tool to analyze the null hypothesis of mean difference, using 4000 permutations. The results reveal that the difference in means is -0.69 and that this value is within the confidence limits, which vary between -2.543 and 2.746. Consequently, with a confidence level of 95% and a significance level of 0.05, it is concluded that the model is accepted.

6. Validation

For validation, the data obtained in the study area was entered into the Vissim software and values close to a new sample obtained in the field were obtained.

6.1. Vehicle Validation

Table 8: Travel time in seconds in the study area and Viswalk

TRAVEL TIME (seconds)	
VISWALK	**FIELD STUDY**
59.5	58.3
50.46	50.7
54.12	51.26
50.14	55.3
59.4	58.9
51.1	52.12
53.47	52.86
51.74	52.11
53.22	52.99
59.69	59.2
53.62	53.9
51.95	50.61
55.1	54.89
53.23	52.45
61.12	60.9

As can be seen, the results obtained from Vissim are close to the results obtained in the field, therefore the modelling carried out in the Vissim software is validated.

Once calibrated and validated, the traffic light cycle of the study area is obtained in Fig 4.

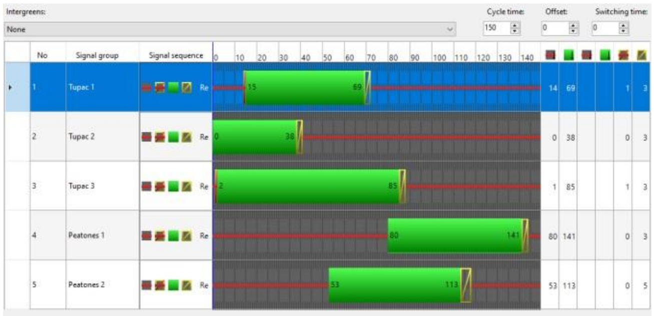

Fig. 4: Current traffic light cycle of the study area

7. Analysis of Results

It is observed in Fig. 5 that the micro simulation in VISSIM is similar to the real one once the model has been calibratedand validated in the current situation.

Fig. 5: VISSIM simulation of the avenues.

7.1. Number of conflicts

In Fig. 6 is illustrated the relationship between the number of conflicts detected and the number of simulations performed in PTV VISSIM. It is observed how the variation in the number of simulations directly affects the number of conflicts identified, providing a visual perspective of the dynamics and frequency of conflicts in the simulated environment. This analysis contributes to a deeper understanding of the interaction and effectiveness of the proposed design in terms of safety and traffic flow. The comparison of these data with the results that will be obtained after implementing the suggested improvements is anticipated.

Fig. 6: Number of conflicts per simulation.

7.2. SSAM

The Fig. 7 shows the simulated conflicts in the current situation of the study area. Pedestrian conflict crowds (red color) are observed on Av. Túpac Amaru. This is because pedestrians become crowded on the central islands of the roads that are too narrow for the number of people gathered, which endangers people with reduced mobility who crowd.

In Fig. 8, a notable reduction in the number of pedestrian conflicts can be observed. The change in traffic light cycles reduced the number of conflicts in the study area on Túpac Amaru Avenue. Likewise, correct signage at the crossings allowed people not to cross on any side that is not permitted.

The Fig. 8 also shows an improvement in circulation with the yellow lines, since a decrease in the number of red dots and a reduction in the concentration of people has been observed. This implementation has contributed to optimizing traffic flow, allowing more efficient mobility in the area. The presence of yellow lines has generated tangible benefits by facilitating traffic management and, as a result, has generated a less congested environment, promoting smoother and safer movement in the area.

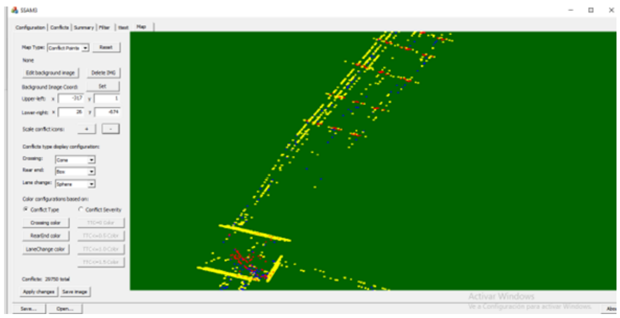

Fig. 7: Heat map of the current state of the study area

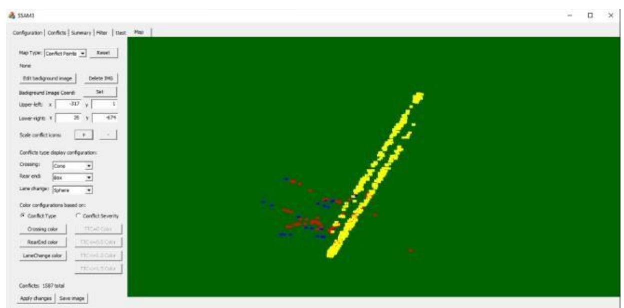

Fig. 8: Heat map of the solution proposal in the study area

7.2. Traffic light time

Optimized traffic light timings were implemented to improve the synchronization of traffic lights around the Hospital. A detailed analysis of traffic flow has been carried out, considering variables such as vehicle volume and the presence of pedestrians. With the help of Vissim, traffic light times are dynamically adjusted to efficiently coordinate vehicular circulation and guarantee safe intervals for pedestrians, especially those with reduced mobility.

After performing the optimal traffic light calculation, these times were analyzed in VISSIM, as seen in Fig. 9.

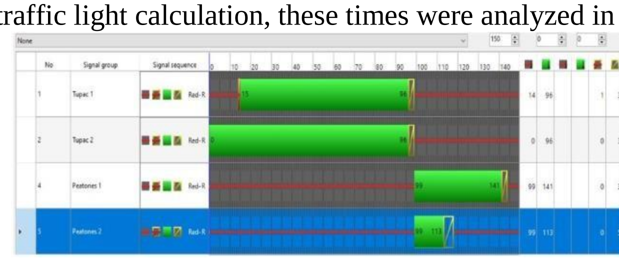

Fig. 9: Improved traffic light cycle

8. Conclusion

- This research process not only provides a deeper understanding of the difficulties faced by users with reducedmobility, but also provides valuable information that can be fundamental for the design of interventions and improvements in the accessibility of the hospital environment.
- Simulation in VISSIM has become an essential resource to support decisions. By simulating the proposal, it has been possible to effectively evaluate the future scenario in comparison with the existing situation.
- By applying the SSAM, it can be observed that in the heat map of the current state with the improvements, thenumber of conflicts was considerably reduced.

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