Pedestrian Behaviour Modeling and Simulation from Real Time Data Information

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Abstract. Accidents of pedestrians sometimes take lives, in Bucaramanga since 2012 pedestrian died by accidents are 179, and 2873 hurt, In a city as Bucaramanga, this means each day at least one pedestrian is involved in a accident. Therefore is necessary to know the causes of accidents in the way to decrease the accidents. One of many reasons to know the causes is with system dynamics, simulating the events of the Pedestrian behavior when accidents occur in risen cities. The implementation simulation joint with technology and research looking for saving lives, reducing the accidental rate, and to implementing or suggesting new policies from the government. This project is looking for the implementation of technology in video records and Deep Learning analysis for the service of the citizens, where a simulation model will be revealing the main variables which intervene in the pedestrian's behavior. As initials results, shows the methodology here implemented, can reach data which was insufficient before thanks to the cameras and software of objects detection, those are the data input for the simulation model, which after to implement a change in a particular spot of Bucaramanga is possible decrease the accident rate in 80% where pedestrians could be involved.

Keywords: Pedestrian Behavior · traffic violation · Dynamic System

1 Introduction

The approach in this project is looking for related research about pedestrian behavior in an urban area, with the aims to reduce accidents in a city. Yang et al [1] made an important contribution, separating two types of pedestrians, the obey law ones or the opportunistic ones, this is an important criterion because is the perception of the pedestrians a city as Bucaramanga in Colombia, have problems with the obey of the traffic authorities as traffic lights. This is just an assumption of the idea, thus, they made a questionnaire evaluating the behavior of the people of chine related to the pedestrian cross path. In this questionnaire, some variables are important in the construction of the model for the micro-simulation, as age, and gender among others. Another related work which evaluates the behavior of pedestrians splited by gender and age, this research

work made it by Chen Chai et al [2], both variables have extra information of the model, which are children and gender from Fuzzy logic-based observation. From this work, born the question of the variables who affect the behavior of the pedestrians. Aaron et al [3] is a work which for the comparison of the reality which is possible to count the variables which are related to the environment, knowing the reality always will be change. This work determines the variables of a micro-simulation which will be part of the causal model for the refined reality. moreover, Camara et al [4], implemented a decision tree to determine the pedestrians' vehicle interaction, this is an important implementation, looking for the designs of new policies for pedestrians in Bucaramanga - Colombia, looking for less critical accidents where pedestrians are involved (see fig. 1), Holland et al [5], see the gender as an important factor in the behavior of a pedestrian in the decision of crossing a pedestrian crossing in a simulation study. In others works the micro-simulation are made with a software it can know the pedestrians event drivers behavior as individuals [6, 7], is the PVT software with the modules of VISSIM and VISWALK.[4]

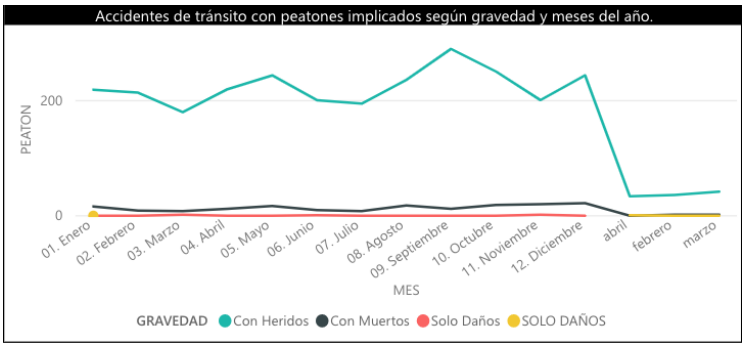

Fig. 1. Pedenstrians' accidents from 2012 in Bucaramanga. (from: http://observatorio.bucaramanga.gov.co/index.php/informacion-publica/)

2 Previous works

The aim of the research will be to identify the variables which intervene in the jaywalking of pedestrians or external causes that produce accidents in Bucaramanga city. To find this causes it will find different scenarios with real-life information and people perception, and hereafter to validate these variables with a micro-simulation model, which will be refined the reality meanwhile is comparing with video-recordings in a spiral process of refined simulation by Jordan (see fig 2), where the validation is repeatedly processed in as endless task, because

[4] http://vision-traffic.ptvgroup.com/es/productos/ptv-vissim/

citizens behavior pattern is not trivial, nevertheless, with a near prediction of the pedestrian behavior it is possible, for to implement new policies and campaigns in the city to improve the social behavior of the citizens. As further work, it will determine new variables which are possible be in the model across the citizens perception, and this will be compared with the made model [8].

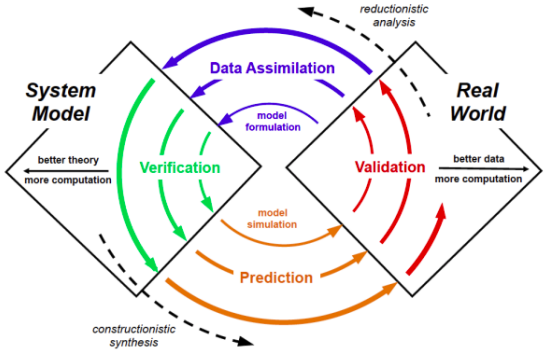

Fig. 2. Inference Spiral of System Science (Jordan 2015)

In the interest to minimize the accidents who involved citizens and vehicles, it is necessary to find the reasons which affect the decision of pedestrians opportunistic ones, or jaywalking, when the traffic light allows the pass of the vehicles or scenarios where do not exists a traffic lights, but the pedestrians must have priority in the way, and the vehicle will stop in that event. A previous work to starts is the empirical analysis of Sanghamitra et al [9], who list the crossing decisions of pedestrians in a cross side of the street based on time gap until the arrival of the next car, where not all the variables could detect it with a tool of the research, but it is possible to recognize a similar behavior in the pedestrians. Another well-know variable which takes place in the pedestrian behavior is the "social force", it occurs when the pedestrians are guided by another citizen, without knowing if the principal citizen decision is correct, but at least have a better vision of the path. Different models for pedestrians can be found Magnetic force, Social force and Benefit-Cost Cellular in the literature. those areas searchable where Teknomo does a review of microscopic simulation of pedestrian, detailing every pedestrian as individual [10], in this work, different variables are necessary for a mathematical model, but different causes could be part of the event of a pedestrian accident. In a simulation model the next causes could be considered in a simulation model:

- Time gap between car and pedestrian [1, 9]
- Social Force [10, 11]
- Environment (Weather, pollution, noise) [12]
- Vehicle Factors [12]

- Human Factors (Driver Skills, Fatigue, Alcohol, drugs, failed looks properly) [12, 13]
- Road Conditions (Corner, straight, wet, dry) [14]

This kind of causes must be identified from different scenarios where the pedestrian can have a particular behavior. Pau et al [15], select the scenarios from a different time of the day, which there is a big quantity of pedestrian in the streets (peak hours) between other time when pedestrians quantity is low. Rasouli et al [16], determines the people who cross-traffic lines in the street and who made a signal with the hands, indicating a petition of the stop to the driver, by the methodology of this research it is necessary looking for different environments, night, day, rain, snow. This work will be no related with the implementation of objects in the image, but, if the action of the pedestrian change in the darkness, or persist, is an environment which is necessary to include in the methodology. In this case, the scenarios in the same place will be during day comparing with the night in certainly hour when pedestrians are crowded, and when not. Kouabenan et al [14], they analyze 55 reports of pedestrians' accidents, randomly selected from a police report in the Ivory Coast, in this research, they analyze the characteristics and circumstances of the accidents.

Thereby, there those previous works, conclude the research, it suggests new solutions in the city, which simplify in new public policies, campaigns, or improvement in a particular spot of the city of the research, this shows them in the next list:

- Accident prevention campaigns [14, 17]
- Road safety policies [12, 18]
- Improve lighting conditions [18, 19]
- Vehicle conditions campaigns [18]

3 Methodoogy

This research work consists in to create a micro-simulation model with the factors which intervene in the citizen behavior (pedestrian or driver) and to refine the simulation with the real-life through some cameras installed in different spots in 5 cities of Colombia, initially: Bucaramanga. This work uses the paradigm of system dynamics; the analysis consists of the following 4 steps:

1. Reviewing the influences on the phenomenon witnessed
2. Modify the simulation model
3. Evaluate the equations created from here
4. The behavior that the observed phenomenon will have, compared with the model created

This process previously described, will be a cycle that will be perfected when the model can add more variables according to the observations of the phenomenon, see Fig 3. If in the simulation it is possible to find the causes who

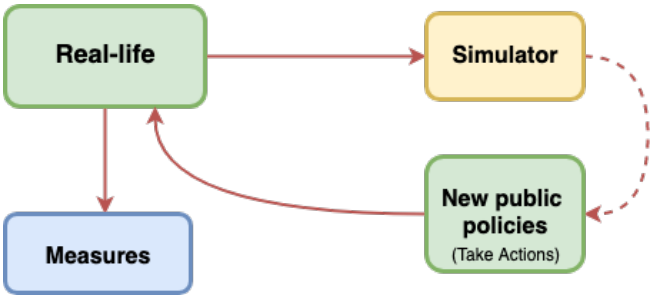

Fig. 3. General Methodology Implemented

have more impact on the pedestrians' accidents in the city, then that causes will be transformed in new public policies to alter the reality and decrease the pedestrians' accidents.

Across a project in the metropolitan area of Bucaramanga by Government of Santander, we have available 900 cameras in 5 cities of Santander-Colombia, for the analysis of the citizens, with the aim of improving civics in the city. Different aims are proposals through those cameras, mobility, public spaces and harmony. With the aim of further a better mobility and to reduce the rate of accidents in the city, this research focuses on pedestrians, thus it decides to select from those cameras the spots were to occur more accidents or an spot where have different conditions. according to the fig 4, the selected camera has the image show it in the fig 5. This particular camera has no traffic lights and is in the zone which collects different variables according to the previous work. Also, it is the second zone with more accidents and has a mixture of architecture, with means, one church, 2 universities, a park, and near, is full of particular homes.

The next step is the scenarios where the video recording of those cameras, it proposes two main scenarios: a main hour in the city and illumination (day/night), the combination of these probabilities is four videos per day for comparing the behavior. Then it selects 10 days to do the comparison that represents 40 videos (1 hour each), in each video-recording, it checks variables to identify the representation of the simulation model according to this methodology, the theoric variables will be initial meanwhile it refines with the real-life in the observations of the video. with all the videos we will have an expectation to found a behavior pattern with the aim to feed the simulation with real and accurate information.

Initially, the simulated model starts from the previous researches carried out to the evaluated phenomenon, bearing in mind that all the models can vary, because the model is created for the particular case of the city of Bucaramanga. From the real-life causes, it can see the measurable causes because of the available cameras of the city. It has tools for the measurable causes, which are video-recordings and software to find objects trow deep learning, this software will

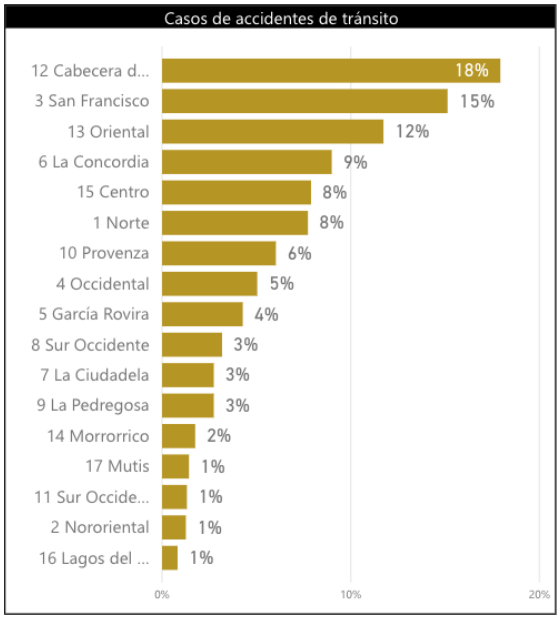

Fig. 4. most accidental areas in Bucaramanga (from: http://observatorio.bucaramanga.gov.co/index.php/informacion-publica/)

rush it the process to find pedestrians in hours of video (Briefcam[5]). Then, with the video-recording and the software, it is possible to obtain the data which is detailed in table 1. this is a piece of quantifiable information, but it is also necessary to have extra information from particular behavior from the video, and the perception of the people who live in Bucaramanga.

3.1 Model and simulation

According to the previous work reviewed in chapter 2, it gathers some causes who directly entail in the pedestrians' accident, who are the aim of this research. otherwise the research will estimate it, if is necessary a micro-simulation [20], looking the pedestrian as an individual, or to identify the general causes seen in the simulation observed, and measurable in the cameras installed for this project (see Fig. 6). In previous researches, many simulations were implemented [8, 12, 16–18] and the solution implemented are new policies, which its solution have a senoidal behavior according to Mendez[17], thereby, is necessary to implement a micro-simulation to see the pedestrian's causes of accident as an individual [1, 10] to determine the causes as individual trying to minimize the accident rate in the city.

[5] https://www.briefcam.com/

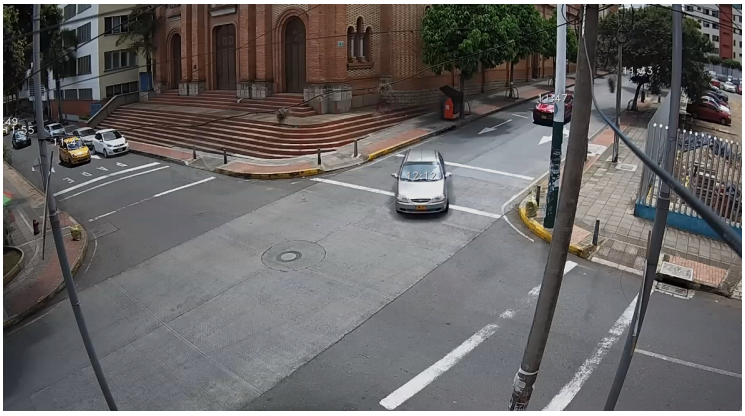

Fig. 5. Vision angle of video camera selected

Variable	Type	Observation
Date of Video	Date	
Range hour	e.g: 21:00 - 22:00 hrs	
Pedestrians who cross the street	numeric	categorized by gender
Not safe events	numeric	those are events which involves an accident
pedestrians against the law	numeric	
pedestrians who cross by the zebra	numeric	
Pedestrians velocity average	numeric	

Table 1. variable of the pedestrian

In the case of a micro-simulation, causes are directly related to variables measurables and which are possible to get it in a video recording, then, from the initial causes evaluated, this work will assess the human factors causes in the micro-simulation for pedestrians as individuals. The numeric data information is not enough, that's why we use the perception of the people to know extra information which is not visible in the videos.

In the accidents some pedestrians endangering their own lives, they interfere with traffic in some way, thus, the motivation is looking for safe crossing. Then through the Viswalk simulation tool[6], it will find the causes of accidents in a

[6] https://www.ptvgroup.com

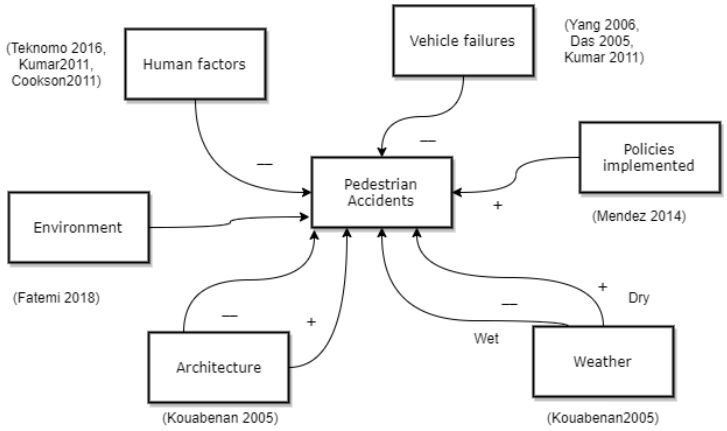

Fig. 6. Causal Diagram for pedestrian accidents

micro-simulation of pedestrians in a specific sector of Bucaramanga-Colombia, using the same methodology represented in Fig 3. First, it will analyze priority, which in Colombia the priority has the cars instead of the pedestrians.

Fig. 7. viswalk micro-simulation in San Francisco neighborhood

To know the causes who a jaywalker could have, we ask to students, and community in general, about how good pedestrians are. the result show in the 2 and 3. This information was used to feed the micro-simulation, for example, and one of the more exciting information, just 69% of people think, the pedestrian is not respected, even in a zebra, the car or motorbike has the priority. This is an

important information, thereby, when the simulation have this rule of priority, the accidents in the micro-simulation starts to appear.

Question	always	often	sometimes	rarely	never
Do you walk on the zebra crossing when you cross road?	42.9%	47.6%	9.5%	0.0%	0.0%
Do you look at the state of traffic lights when you cross road? Answers	95.2%	4.8%	0.0%	0.0%	0.0%

Table 2. Pedestrians' behavior at intersections

Question	always	often	sometimes	rarely	never
In general conditions	0.0%	9.5%	23.8%	33.3%	33.3%
In a hurry	14.3%	23.8%	38.1%	19%	4.8%
Long duration of red light	14.3%	14.3%	9.5%	33.3%	28.6%
Presence of other pedestrians who violate traffic signal	9.5%	9.5%	9.5%	19%	52.4%
Low traffic volume	33.3%	38.1%	14.3%	4.8%	9.5%
High traffic volume	19%	9.5%	0.0%	23.8%	47.6%
Policeman is on duty at the intersection	23.8%	4.8%	14.3%	9.5%	47.6%

Table 3. Probabilities of pedestrians' signal non-compliance under specific situations

The quantifiable information from the video recording, from the spot of the city, is showed in the table 4. With the information about the perception of the people and the numeric information, the microsimulation starts to have information. In order to reach any kind of change behavior, we include a road speed reducer in one of the vehicular streets, where they have to decrease the speed to 2km/hr. This small but significant change in the "reality" according to the simulation is possible to save more than 80% of the people related in an accident in that particular spot with the associate information.

Variable	Type	Observation
Date of Video	22/06/2019	
Range hour	e.g: 9:00 - 10:00 hrs	
Pedestrians who cross the street	316	70% man and 30% woman
Not safe events	0	not registered in the video
pedestrians against the law	2	
Vehicles in the video	668	
cars and motorbikes vehicles velocity average	60km/hr	

Table 4. The quantifiable information from the video recording

4 Conclusions

The system model created, will help to determine the fittest variables which are more important in the act of unsafe crossing of the pedestrians in Bucaramanga, moreover, the system created will be transferred to another place with a similar environment where is possible to have the same scenarios to compare the pedestrians' conduct, looking to find a pattern behavior. The implementation with a small change in architecture it means a significant number of saving people's lives. Then the methodology proposed is a good first step to use Infrastructure (cameras) and information (video-recording) in order to build a smart city in Bucaramanga.

5 Future work

With the methodology implemented, it is possible to analyze different causes seen in this research, associated with weather, architecture, people behavior, vehicle conditions, even policies implemented.

6 Acknowledge

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