Multi Agent system Randomized in Road Traffic

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Abstract

In recent years, the rapid growth of road traffic density in the world generates a rising request for tools that can be used to analyze and control the traffic networks. Microscopic traffic simulation[1,2,3] has proven to be one of the most useful tools for analysis of various traffic systems. Thus microscopic traffic simulation has become an ever increasing field of research and development. In this paper we present a new model for microscopic traffic simulation; Traditional traffic simulation models neglect some real-life factors that need to be considered, such as the effect of random distribution in the entry of lane hence ,this paper presents the development of a concept and an associated architecture called the MAS2RT (Multi Agent system Randomized in Road Traffic), which is based on the combination of Multi-Agent Systems (MAS) [4,5], Poisson distribution in urban Traffic and a stochastic model [6,7] to capture the randomness of individual agent. The second contribution of this paper is about the internal structure of mobile agents[8], initially reacts according to the instructions of the Main agent (MA) and in the case of a lack of dynamic information, the mobile agents take decisions based on their experiences accumulated during previous interactions.

The obtained results illustrate that using the randomness in the reaction of agent enhanced greatly the performance of simulation.

Keywords: *Multiagnet system, microscopic traffic, random distribution, poission law*

1. Introduction

Simulation is a process based on building a computer model that suitably represents a real or proposed system which enables to improve their performance. It is also possible to predict the behavior of all agents interacting in the traffic network, as it can provide the characteristics of the road traffic. Furthermore, simulation of road traffic is also useful throughout the designing of new traffic structures;it helps predicting the future behavior of the new structures and their integration into the current traffic network. In order to model the real traffic situations as accurate as possible, the simulation must be very detailed. Therefore, the main objective of our research is to develop a new microscopic approach in the MAS introducing the notion of randomness action of agents in the network, which are distributed at the entry level according to Poisson Law.

The application of Poisson Law distribution on the traffic problems had been used in the last decades. Certain applications were discussed by Kinzer [15] in 1933, Adams [16] in 1936, and Green shield [17] in 1947.

Hence, Microscopic Traffic Simulation has proven to be one of the most useful tools for analysis of various traffic systems.In the microscopic simulation, every individual vehicle is modeled as a single simulation object. These simulated vehicles drive along the streets, change traffic lanes and their driving directions as they interact with each other. Each simulated vehicle has its own immediate position, speed, and acceleration …etc. The most important models in this area are the car following model [9] and cellular automaton model [10].

Multi-Agent System (MAS) has brought a new vision to study the microscopic phenomena and complex situations with emphasizes the interactions of components of the systems. urbain. In literature, the MAS is one of the newest area of research in the artificial intelligence (AI), it has started in the early 90s with [Mulate 90], [Minsky 94], [Ferber 95], as an attempt to enrich the limits of classical AI[11]. The foundations of the MAS are interested in modeling human behavior in the real world with mental notions such as knowledge, beliefs, intentions, desires, choices, commitments (Shoham, 1993).

There are various definitions of the concept agent [12, 13, 14] in the contemporary literature; however, the definition that we adopted, and which covers the characteristics of agents that we developed, is that proposed by Jennings, Sycara and Wooldridge [JEN 98]:

For Jennings, Sycara and Wooldridge an agent is a computer system, located in an environment, which is autonomous and flexible to meet the objectives for which it was designed. As far as MAS is concerned, according to Ferber [Ferber 95] a MAS is a system composed of the following: Environment, a set of objects in space; a set of agents who are active entities of the system; a set of relationships that binds objects together; a set of operations allowing agents to perceive, destroy, create, transform, and manipulate objects.

Many algorithms have been developed to simulate the road traffic including TRANSIMS [18], AIMSUN2 [19], and EMME/2 [20] .Yet no models combine the MAS and Poisson Law distribution.

In this paper, in order to improve the accuracy of simulators, therefore the accuracy of the results obtained, a new hybrid approach is proposed to improve the effectiveness of the simulation. The structure of this paper is divided into five sections; the first section provides a general overview microscopic simulation. The second section describes our architecture. Section three presents the integration of our architecture in AIMSUN2 Simulation Process. The experimental results are presented and discussed in Section four. Finally, Section five concludes the paper.

2. Architecture Description

In traffic simulation two processes can be distinguished. First of all, the initialing process is composed of modules responsible of starting the simulation. The second process or the main process is, in the case of our architecture, comprised of multiple interacting intelligent agents.

The main process consists of a distribution model which is used to define the affectation method in the network. The interaction model is used to regulate the interactions between the agents.

In design of this architecture, we explicitly aimed at building a distributed and decentralized solution, where each agent performs its own task. The resulting architecture will then capitalize on effective use of distribution to avoid bottlenecks and achieve scalability with an increase in a number of transactions.

The architecture is schematically depicted in Fig. 1 which shows the architectural components. The Main Agent (**MA**), which is the main element of this architecture, serves to distribute the Execution Agents (**EAs**) – vehicles - in the network following the distribution model and supports these agents to locate all required resources designed by Zone Agent (**ZA**). This latter present the ground in which the **(EAs)** interact among each other according to the interaction model.

ZA is the agent responsible of building network from a database that contains all the elements necessary to build a network (roads, crossroads ...). Besides, during the simulation, it provides all information about the positions of **EAs** to the Control Agent (**CA**).

CA is designed to build a re-active and persistent architecture. This agent records the evolution of architecture caused by changes of existing resources in the interaction database which discern the change in the behaviors of the **EAs**.

In the proposed approach, **CA** collect all information of the execution agents Thus, the accumulated information could be shared between agents, increasing overall efficiency of the system.During registration, the **MA** aims to retrieve **EAs**' characteristics in the interaction database; hence, **EAs** update their knowledge about the other agents. This process of update is decided according to the collected information by the **CA**.

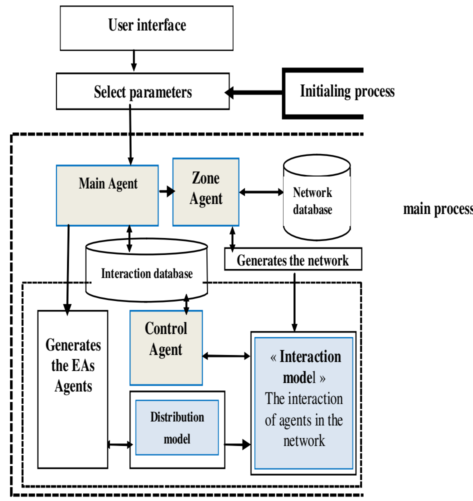

Figure 1. Architecture of MAS2RT

Figure 1 sheds light on the links between all agents and models of the architecture**.** In order to simplify the simulation we limit the use of execution agents to vehicle.

2.1 Distribution Model

The distribution model is used to simulate the entry of **EAs** in the network. The theoretical study of conditions affecting the traffic of **EAs** on a lane requires the constant use of probability theory.

The distribution of vehicles follows arbitrary patterns which makes it impossible to predict the number of vehicles in each lane. Thus, considering sequence (T_n) n ≥ 0 in which T presents the time of entry of vehicles in the lanes. This process applies to many situations such as the arrival of customers at the CTM, the emission of radioactive particles…etc Generally speaking; this type of process is relevant to recurrent cases. In our new model, we have considered the entry of vehicles as following: as T presents the successive time of the entries. Therefore, the sequence (T_n) n $\geq$ 0 is random variables in R+, the set of positive real numbers T_n is a stochastic process which verifies:

1. $T_0 = 0$
2. $T_0<T_1<T_2<\ldots<T_n$, the series is strictly increasing which proves there are not two simultaneous entries.
3. T_n tends to $+\infty$ as n tends to $+\infty$

In this sense, this process is associated with a counting process which provides at each instant t, the number N(t)of entries in the interval of time [0, t]. (N(t)) t E R+ is a stochastic process[21,22,23] in continuous time, which verifies:

1. : $\forall$ t ,$0\leq t_1 \leq t_2 \leq \ldots\leq t_k$, the random variables $N(t_{i+1}) - N(t_i)$, $0\leq i \leq k-1$, are independents.

This property expresses the fact that increase process is independent.

2. The number of entries in an interval of length h follows the law of Poisson of a parameter $h\lambda$

$-\forall t, P(Nt + h - Nt = 1) = \lambda . h + o(h)$ quand $h \to 0$

$-\forall t, P(Nt + h - Nt > 1) = o(h)\ quandh \to 0$

These properties are verified by the above mentioned phenomena, and are characteristic of the Poisson process. The coefficient of proportionality λ involved in the second property is the average number of vehicles per unit of time. We note: $Nt \sim P(\lambda t)$. if $Nt \sim P(\lambda t)$, and then the waiting time between two successive realizations $T (= \Delta t)$ is a random variable distributed according to the exponential law $Exp(\lambda)$ density $\lambda e - \lambda t$ for $t > 0 average \frac{1}{\lambda}$.

In the following, U is independent realizations of the uniform distribution on$[0,1]$, then

$$T_{0i}=T_{0i-1}-(\ln U)/\lambda \text{ and } V_{0i}= V_{em} + \sigma_v*(-2Ln(U1))^{1/2}*\cos(2\pi U2)$$

When T reaches the value $T_{0i}=T_{0i-1}+\Delta t_i$, with $\Delta t_i =-(\ln U)/\lambda$,the i^{th} vehicle starts with the speed V_{0i} (see algorithms generating vehicles)

2.2 Algorithms generating vehicles

The algorithm calculates for each vehicle I, the time of entry into the network T_{0i} and the initial speed V_{0i}.

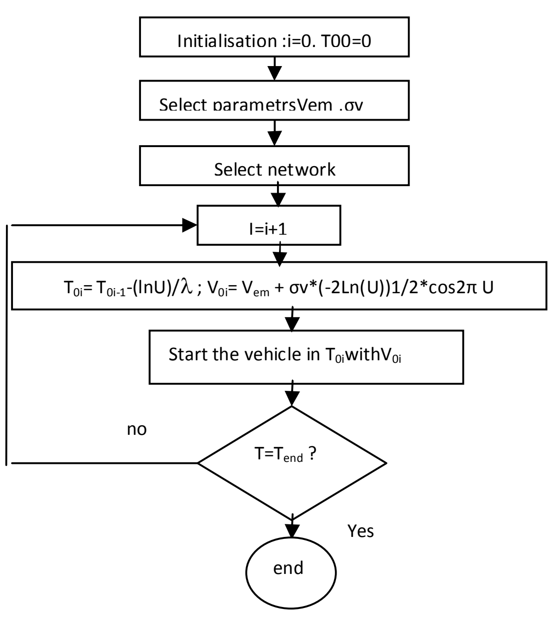

Figure 2 .Distribution Model

T_{0i} is calculated by incrementing T_{0i-1} with the value Δt_i which is distributed according to the exponential law $Exp(\lambda)$, where λ is the average number of vehicles per unit of time. While "V0i" is distributed according to a normal distribution with average Vem – Vem presents the average speed- and standard deviation σv – σv presents the standard deviation of speed-.

The normal (Gaussian)[24] distribution is often selected for a stochastic process as an approximation of a more complex distributions, or when few information are provided about the true distribution of a random variable.

2.3 Interaction Model

In microscopic models, traffic is described at the level of individual vehicles and their interaction among each other. Normally, this behavior is captured in some set of rules which determine when a vehicle accelerates,decelerates, changes lane; in addition, it regulates how and when vehicles choose and change their routes according to their destinations, and how they react to traffic and route information along the way.

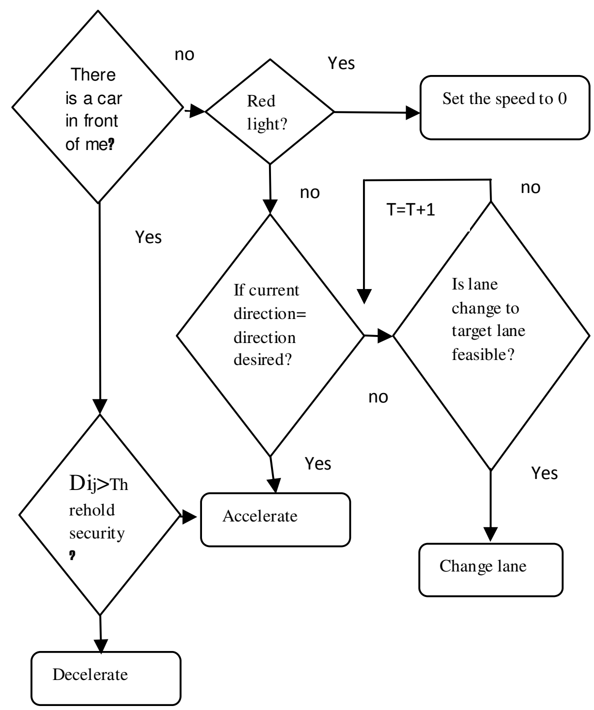

Figure 3.Interaction Model

In the first case, the vehicles are distributed randomly on the network according to the distribution model defined for each junction of the network. The vehicles react to the information concerning their next action. Models differ according to the various answers to the key questions: What is the nature of the action adequate ? To what stimulus it does react? and how do we measure the characteristics of the other agents? The first and simplest model correspond to the case when the response is represented by the acceleration or deceleration of the vehicle.

3. Integrate our Approach in Aimsun2

In this section, a hybrid method is proposed which incorporates the process AIMSUN2, especially the equation of acceleration and deceleration. The choice of this process is based on its performance in the simulation and its valid results in practice. AIMSUN2 (Ferrer& Barceló, 1994) was one of the first microscopic models ever developed; it aims to create a tool that could reproduce the dynamic aspects of traffic modeling and provides a very detailed road network.

According to Gipps [21] in the **AIMSUN2** , the speed of the vehicle i-1 is controlled by three conditions. The first condition ensures that the vehicle does not exceed the average speed . The second condition ensures that the vehicle is accelerated to the desired speed with a rate of acceleration which increases the initial speed. The third condition ensures the decrease of the vehicle speed to zero as it approaches the desired speed. The combination of these conditions results in equation (1)

If Xn(t) and Xn+1(t) are the positions of the leader and follower respectively at time t then:

$$\ddot{x}n + 1(t + T) = \lambda|\dot{x}n(t) - \dot{x}n + 1(t)|and \quad (1)$$

$$if\dot{x}n(t) > \dot{x}n + 1(t)then\ddot{x}n + 1(t + T) > 0$$

$$if\dot{x}n(t) < \dot{x}n + 1(t)then\ddot{x}n + 1(t + T) < 0$$

$$if\dot{x}n(t) = \dot{x}n + 1(t)then\ddot{x}n + 1(t + T) = 0$$

Taking into consideration this equation, (Gipps, 1981), (Mahut, 2000)[26], develops an empirical model consisting of two components: acceleration and deceleration defined as a function of variables that can be measured. The first represents the intention of a vehicle to achieve certain desired speed; while, the second reproduces the limitations imposed by the preceding vehicle when trying to drive at the desired speed. This model states that the maximum speed a vehicle (n) can accelerate during a time period (t, t+T) is given by:

$$Vn(t+T) = Vn(t) + 3{,}6[2{,}5an\,T\,(1 - Vn(t)/Vn)\sqrt{(0{,}025 + \left(\frac{Vn(t)}{Vn}\right)}] \quad (2)$$

Where Vn(t) is the speed of vehicle at time t (km/h); an is the maximum desired acceleration rate of vehicle n (m/s); T is the driver's reaction time (s); and Vn is the desired speed of vehicle n or the vehicle-specific free-flow speed (km/h).

The limitations imposed by the presence of the leader vehicle is:

$$Va(n, t+T) = d(n)T$$

$$+\sqrt{d(n)^2T^2 - d(n)[2\{x(n-1,t) - s(n-1) - x(n,t)\} - v(n,t)T] - \frac{v(n-1,t)^2}{d'(n-1)}} \quad (3)$$

Where: d (n) (< 0) is the maximum deceleration desired by vehicle n; x (n, t) is position of vehicle n at

time t; x (n-1, t) is position of preceding vehicle (n-1) at time t; s (n-1) is the effective length of vehicle

(n-1); d' (n-1) is an estimation of vehicle (n-1) desired deceleration.

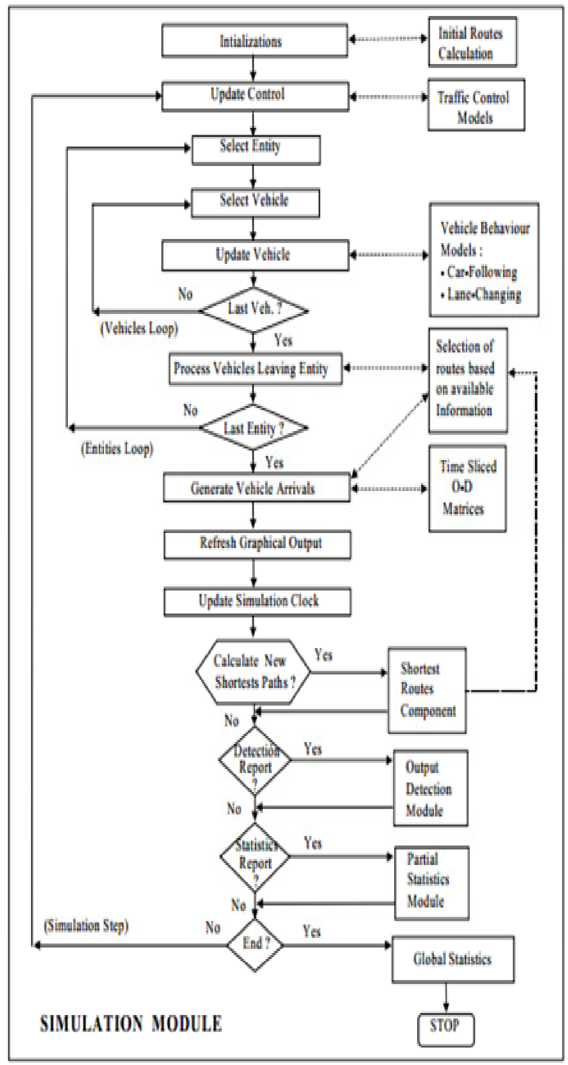

Figure 4.AIMSUN2 Simulation Process

AIMSUN2 process is characterized by different types of traffic control including traffic light, the priority of the ways, and ramp metering. In this model see figure 4. In this sense, our new model (see figure 5)is based on the same process, except that we included the distribution model and the interaction model. Both inserted models make the simulation more real and the results more eligible.

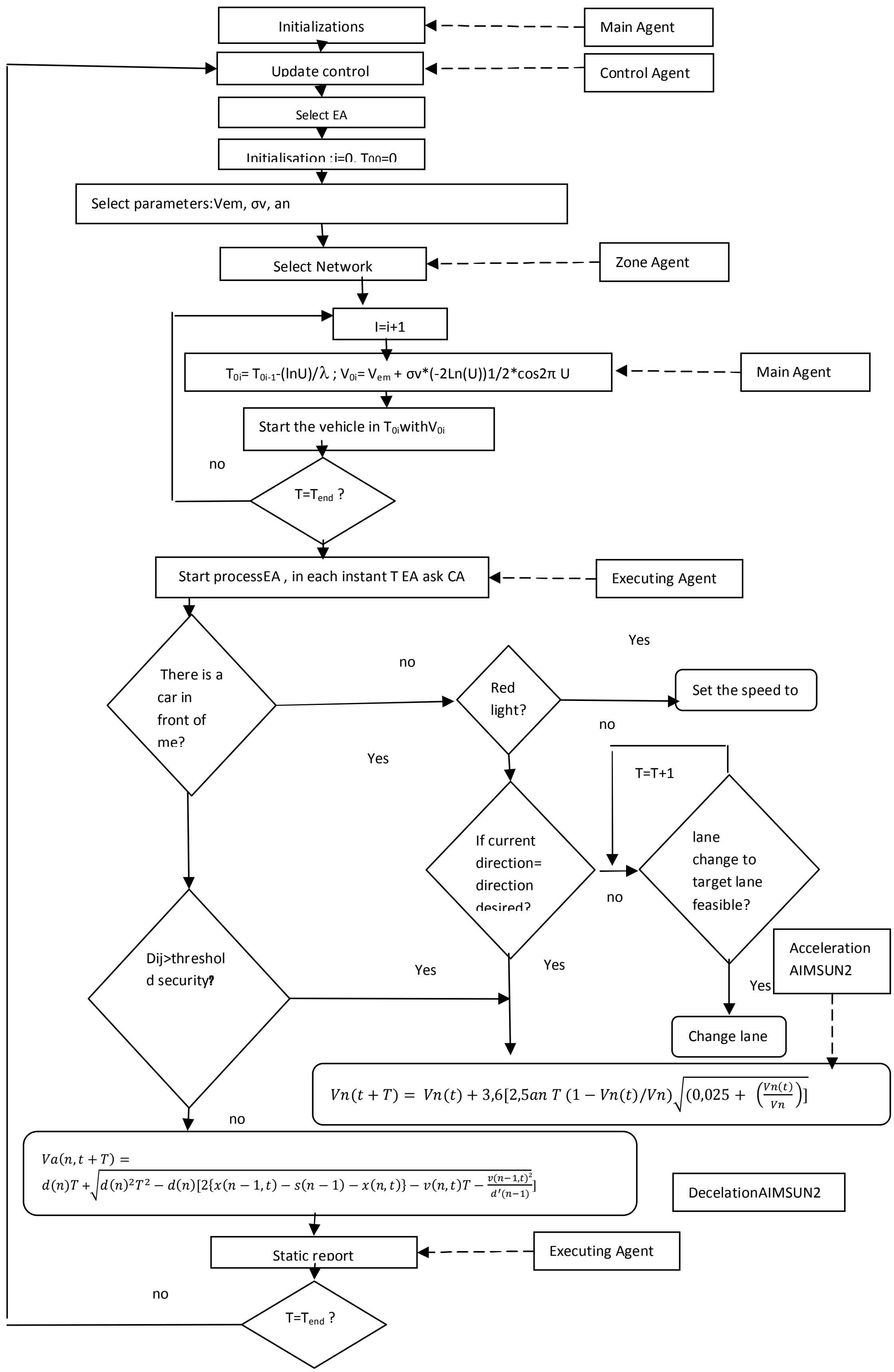

Figure 5. MAS2RT process

4. Experiment and Validation

In this section, in order to assess the performance of the proposed hybrid algorithm, a series of experiments is conducted to illustrate that our distribution model and interaction model can improve the microscopic traffic simulation.

We present two sets of experimental results. Our first set of experiments examines the input speed of the vehicles in a section of the road; the second one evaluates the speed average in an interval of speed. Both sets of experiments are compared to the observed results during one hour of real interaction, see (table 1& table 2)

Table 1 .the entry speed in the lane

T	**Speed observed (km/h)**	**Speed simulated(km /h)**
T1	42	41,1119704
T2	51	51,3086948
T3	57	53,3598941
T4	43	39,3539766
T5	56	43,1623830
T6	55	40,9921566
T7	45	47,0093724
T8	39	47,5420921
T9	59	45,4179147
T10	50	48,9087991
T11	55	59,4983246
T12	52	45,4543754
T13	51	49,1936663
T14	46	41,370824
T15	43	48,3736373
T16	47	55,963108
T17	48	45,9071494
T18	52	45,7218993
T19	56	34,4250076
T20	58	40,1402877

In this experiment, we have set 40KM\h as the average speed and 7KM\h as the standard deviation. In this experiment, we focused only on the first twenty vehicles; the percentage of the vehicles speed is presented in table 2. We observe that the simulated speed is randomly distributed at the level of entry, which resembles the results observed in the reality. Additionally, most of the values examined in table 1 are around the average speed; the speed of 90% of vehicles is between 4060KM\h and 60KM\h as shown in table 2.

Table 2 .percentage of vehicle's speed

Observed

values with speed in[0-20[		**values with speed in[20-40[**	
v	P(x=v)	v	P(x=v)
0	0,0003	20	0,136581215
5	0,0001	25	0,074285714
10	0,003	30	0,096418516
15	0,006	35	0,035914281

values with speed in[40-60]		**values with speed>60**	
v	P(x=v)	v	P(x=v)
40	0,178571421	65	0,12
45	0,451153116	70	0,09
50	0,079428571	75	0,02
55	0 ,071428571	80	0,0001

Our simulation

values with speed in[0-20[		**values with speed in[20-40[**	
v	P(x=v)	v	P(x=v)
0	0	20	0,006120071
5	0,000833333	25	0,024903007
10	0,000785714	30	0,046153146
15	0,000416190	35	0,190406111

values with speed in[40-60]		**values with speed>60**	
v	P(x=v)	v	P(x=v)
40	0,269230769	65	0,142857143
45	0,176113007	70	0
50	0,006923017	75	0
55	0,20008795	80	0

5. Conclusion

In this work, we have discussed the randomly distributed simulation of the road traffic. We described main aspects of the general computer simulation and the specific features of the computer simulation in the field of road traffic. Then, we proceeded with the description of the main issues of the distribution model and the interaction model. To evaluate the efficiency of these two models we have integrated them In AIMSUN2 ; theobtaintedresultsprovedtheeffectivnessofthenewmodelanditsrelevancetoreality.

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