FOLLOWING CAR ALGORITHM WITH MULTI AGENT RANDOMIZED SYSTEM

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ABSTRACT

We present a new Following Car Algorithm in Microscopic Urban Traffic Models which integrates some real-life factors that need to be considered, such as the effect of random distributions in the car speed, acceleration, entry of lane… Our architecture is based on Multi-Agent Randomized Systems (MARS) developed in earlier publications.

1 INTRODUCTION

Traffic simulation or the simulation of transportation systems are computer models where the movements of individual vehicles travelling around road networks are determined by using mathematical models to evaluate and analysis the various traffic conditions. In the literature, simulation is a process based on building a computer model that suitably represents a real or proposed system which enables to improve their performance.

In simulating mobile systems, it is important to use mobility models that reflect as close as possible the reality of their behaviour in real-world including a traffic generation model, and take into account driver behaviour or specific characteristics of the urban environment.

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 modelled as a single simulation object. They are the only modelling tools available with the capability to examine certain complex traffic problems [9] [10].

In the mathematical analysis, Traffic flow has been considered as a stochastic process. Adams in 1936 [22] proposed the idea of vehicles arrival at the entry of lane as a random process and verified its relevance to theory and observations. Afterwards, Greenberg in 1966 [23] has found a connection between the microscopic traffic flow theory and the lognormal follower headway distribution. In 1993, Heidemann [24] developed a new approach in which he applied the theory of stochastic processes to analytically derive the headway distribution as a function of traffic density. His approach may provide a link between the macroscopic traffic flow theory and the headway distributions.

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. 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 Minsky [25], Ferber [26], as an attempt to enrich the limits of classical AI [11].

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The foundations of the MAS are interested in modelling human behaviours in the real world with mental notions such as knowledge, beliefs, intentions, desires, choices, commitments [27].

There are various definitions of the concept agent [12, 13, 14] in the contemporary literature; however, the adopted definition which covers the characteristics of agents developed in the new model, is that proposed by 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 [26], 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.

Therefore, the main objective of the research is to develop a new microscopic approach in the MAS combining the notion of theoretical mathematic model, especially the statistic model, and the main characteristics of the Multi-agent System. Such a combination would pave the way for a real description of the phenomena.

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

In order to improve the accuracy of simulators, therefore the accuracy of the results obtained, we proposed a new hybrid approach to improve the effectiveness of the simulation. In previous papers [28, 29, 30], we developed a new architecture of MAS to handle Urban Road Traffic, and Multi Agent Randomized System (MARS) allowing agent's stochastic behaviour.

In this paper, we develop a new Following Car Algorithm to describe influences and impacts between agents in Urban Road Traffic. The first section presents system architecture; the second explains MARS; the third develops the proposed following car algorithm. Finally, Section four concludes the paper.

2 MAS FOR VEHICLE ROUTING

In phenomena of road traffic, vehicles continually enter and leave the system and are dispersed over the spatially distributed road infrastructure. Therefore our architecture schematically depicted in Fig. 1 consists of a number of autonomous entities, called Execution Agents (EAs) – vehicles - that are situated or embedded in an environment designed by Zone Agent (ZA). The Main Agent (MA), which is the main element of this architecture, serves to distribute the (EAs).
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 behaviours 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.

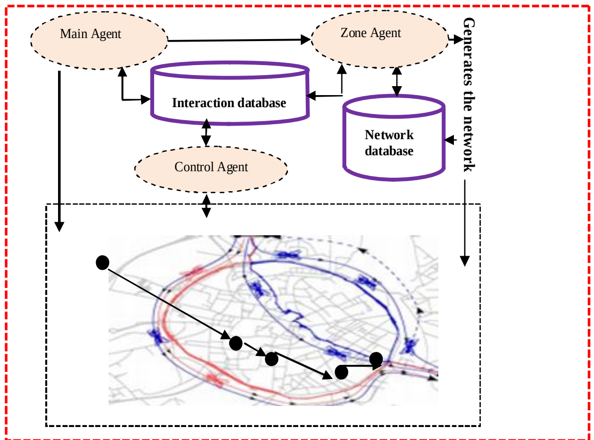

Figure 1. Architecture of MAS2RT

3 TRAFFIC GENERATION

3.1 Distribution model

Modelling the entry of vehicles in the lane presents a crucial step in urban traffic flow simulation. The distribution model is used to simulate the entry of vehicles in the network and describes how vehicles arrive at a section. The theoretical study of conditions affecting the traffic of vehicles on a lane requires the constant use of probability theory. Modelling the vehicle arrivals at the level entry can be produced in two related methods. The first one focuses on number of vehicles arrived in a fix interval of time, the second one measures the time interval between the successive arrivals of vehicles. The vehicle arrival is obviously a random process.Observing the arrivals of vehicles at the entry of the road, one can notice different patterns; some vehicles arrive at the same time, others arrive at random instances.

The distribution of vehicles follows arbitrary patterns which makes it impossible to predict the number of vehicles in each lane. Thus, considering sequence $(Tn)n\geq 0$ in which Tn presents the time of entry of vehicle n in the lanes. This process applies to many situations such as the arrival of customers at the CTM, the emission of radioactive particles… Generally speaking; this type of process is relevant to recurrent cases. In the new model, the entry of vehicles is considered as following:

The sequence $(T_n)_{n\geq 0}$ presents the successive time of the entries, is random variables in R+, the set of positive real numbers, a stochastic process which verifies:

1. $\forall\ T_0<T_1<T_2<\ldots<T_n$, the series is strictly increasing, T_n tends to $+\infty$ as n tends to $+\infty$
2. $\forall\ j\neq k$, T_j-T_{j-1} and T_k-T_{k-1} are independents.
3. Stationary, that is the number of realizations, in some interval [a, a+t] depends only of the length t and not of the origin a of that interval, and hence will be denoted N_t
4. $\forall t, P(N_{t+h} - N_t = 1) = \lambda.h + o(h)$ as $h \to 0$
5. $\forall t, P(N_{t+h} - N_t > 1) = o(h)$ as $h \to 0$

These properties are characteristic of the Poisson process. The coefficient of proportionality λ involved in the 4th property is the average number of vehicles per unit of time. We note: $N_t \sim P(\lambda t)$. If $N_t \sim P(\lambda t)$, then the waiting time between two successive realizations $T (= \Delta t)$ is a random variable distributed according to the exponential law $Exp(\lambda)$ with density $\lambda e^{-\lambda t}$ for $t > 0$ and average $\frac{1}{\lambda}$.

In the following, U refers to independent realizations of the uniform distribution on $[0,1]$. Then instants of introducing vehicles can be generated by:

$$T_{0j} = T_{0j-1} + \Delta t_j = T_{0j-1} - \ln(U) / \lambda \quad (1)$$

The speed V_{0j} of vehicle j at its introduction instant T_{0j} can be generated using normal distribution with mean V_{em} and standard deviation σ_v using Box-Muller Algorithm by:

$$V_{0j} = V_{em} + \sigma_v \sqrt{-2\ln(U_1)}\, \cos(2\pi U_2) \quad (2)$$

4 MICRO-SIMULATION ALGORITHMS

Most micro-simulation algorithms use various driver behaviours to simulate the react of each vehicle on a network (acceleration, deceleration, and speed), however the MAS can improve communication between the vehicle and provide a more realistic simulation.

The position and speed of each vehicle on the network is updated once per second based on CA agent.

Default vehicle and driver characteristics can also be modified to properly analyze and interpret the simulation.

Once a vehicle is assigned performance and driver characteristics, its movement through the network is determined by two primary algorithms:

- generating vehicles
- Car following

There are other algorithms which influence vehicle behavior, such as those which govern queue discharge and traffic signal control, but car following, lane changing, and gap acceptance are perhaps the most important and are common to all traffic simulation models. As CORSIM, AIMSUN

4.1 Algorithms generating vehicles

When T reaches the value T_{0j}, the jth vehicle starts with the speed V_{0j} (see algorithms generating vehicles)

```
loop
Initialization: j=0, T00 =0
Select parameters Vem , σv
Select network
   if T<=Tend
         calculate T0j= T0j-1-(lnU)/ λ (1); V0j= Vem+σv √(−2ln (U1)) cos(2πU2)
          Start the vehicle j in T0j  with speed V0j
    end if
end loop
```

Figure 2 .Distribution Model

T_{0j} is calculated by incrementing T_{0j-1} with the value Δt_j which is distributed according to the exponential law Exp(λ), where λ is the average number of vehicles per unit of time; while V_{0j} is distributed according to a normal distribution with average V_{em} and standard deviation σ_v.

4.2 Car following

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 adequate action ? To what stimulus it does react? And how to 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.

In what follows, we use simplified notations and situations to be enhanced later. We consider roads with only one lane. Indexes j and k nominate vehicles; j being the last introduced one in the considered section. Acceleration is supposed a positive parameter “a” and deceleration a negative parameter “d”.

Every vehicle k moving in the road is modelled as an agent, which has its own entry time T_{0k}, position X_{Tk} at time $T>T_{0k}$, speed V_{Tk} at $T> T_{0k}$, and acceleration a>0 or deceleration d<0. To reduce algorithm complexity, we drop the “T” index; x_{Tk} is denoted x_k meaning the actual position of vehicle k. Same for V_k,

The algorithm generates the entry time T_{0k} of vehicle k, but k can’t get in the network until road is free, i.e x_k-x_{k-1} > $\alpha. \Delta.V_k$. Otherwise, k will be delayed and T_{0k} incremented to stay being the effective entry time of k. Here α is a determined parameter. We take α=2 in our simulations, so that, when started, vehicle k doesn’t reach and hit him leader. While Δ is just the time increment (to simplify $\Delta = 1$).

When in the network, k will react to leading vehicle, if any, designed by k-1: $\Delta x_k = X_k - X_{k-1}$; is the distance between k and k-1; $\Delta V_k = V_k - V_{k-1}$, is the difference between speed of k and that of k-1. If k and k-1 are not too close ($\Delta X_k > \alpha.V_k$) and $\Delta V_k > 0$ ($V_k < V_{k-1}$), vehicle k has to accelerate. If k and k-1 are too close ($\Delta X_k < \alpha.V_k$) and $\Delta V_k < 0$ ($V_k > V_{k-1}$), k has to decelerate. Model of Barcèlo and al. [19] simplify to:

$$V_k = V_k + 2.5a\left(1 - \frac{V_k}{V_{em}}\right)\sqrt{0.025 + \frac{V_k}{V_{em}}} \qquad (3)$$

$$V_k = d + \sqrt{d^2 - d\left[2(X_{k-1} - S_{k-1} - X_k) - V_k - \frac{V_{k-1}^2}{d}\right]} \qquad (4)$$

Otherwise, k will continue with the same speed. Here S_k is the effective length of vehicle k, maintained constant in our simulations. Vehicle k will continue its progress in the network: X_k becomes $X_k + V_k$.

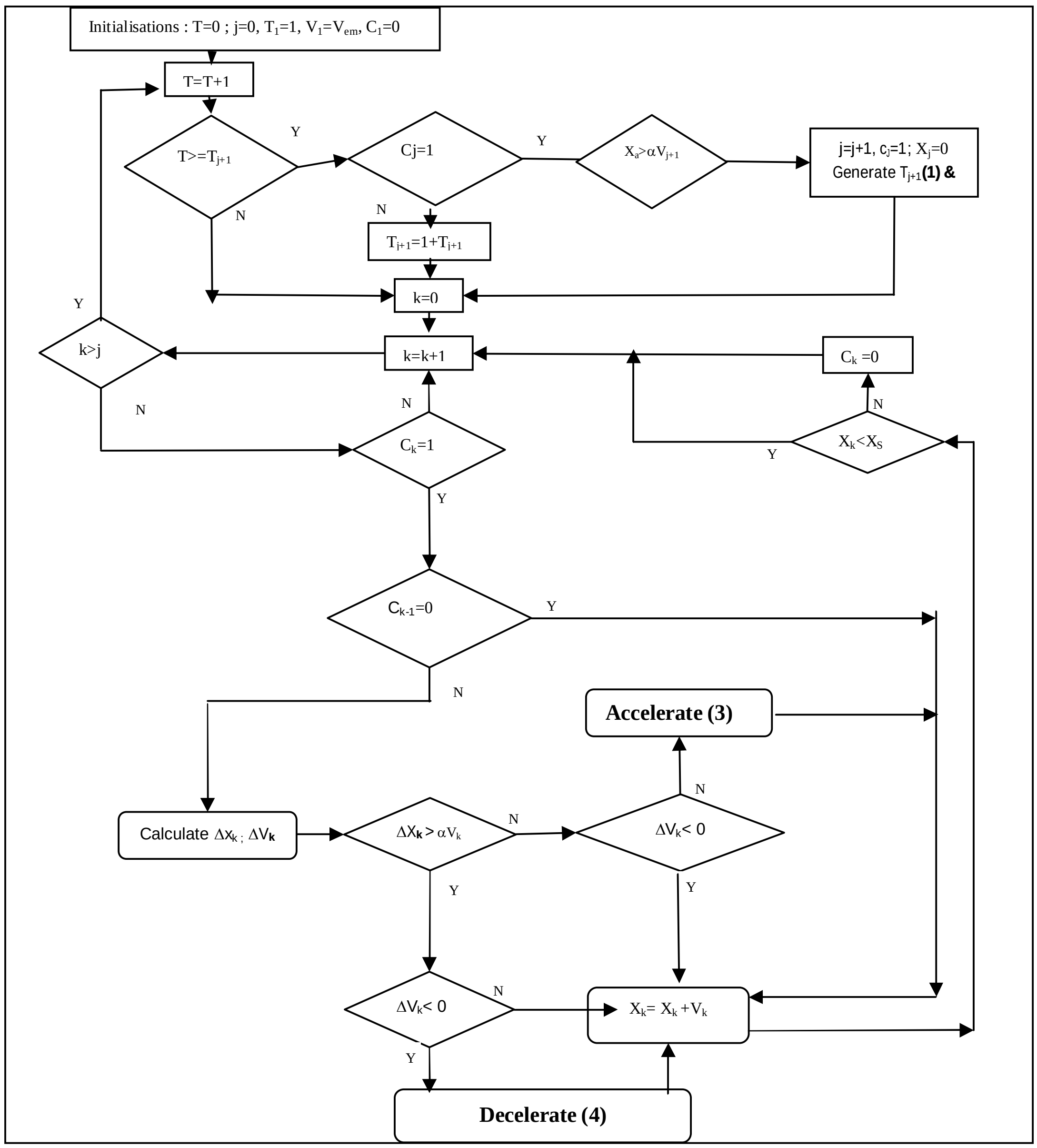

Figure 3 .Proposed Following Car Algorithm

5 CONCLUSION

This work discussed the randomly distributed simulation of the road traffic. It described the main aspects of the general computer simulation and the specific features of the computer simulation in the field of road traffic. The first section introduced the topic. The second section provided a general description of the Microscopic traffic modelling software. The third section proposed Multi-Agent architecture proceeded with the description of the main issues of the distribution model and the interaction model as well as the stochastic distribution model. The fourth described proposed Following Car Algorithm. We are now running simulations using NetLog and Jade/Java, results will permit to adjust parameters and distributions to make our model closer to reality.

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