# Virtual lanes interest for motorcycles simulation.

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### Abstract

Driving simulators are used in many domains such as driving psychology, ergonomics, training. To be the most realistic, a driving simulator needs both good quality of 3D visual rendering and good quality of the associated traffic simulation. This work takes place in the traffic simulation framework, more precisely on the moving level of the motorized two-wheels vehicles. Indeed, these users are not present in the current traffic simulation because of their atypical movings. We support that the environment structured by the road marking is not adapted to the motorcycles. In this article, we propose a model where the motorcyclist dynamically structures the road using virtual lanes built according to the presents actors. The problem of the contra-flow traffic will not be treated here. We offer in particular a lane changing algorithm which allows this kind of vehicle to move efficiently in heavy traffic. Eventually, we validate experimentally our algorithm: we highlight the microscopics characteristics binded to this type of vehicle by comparing real data and results of the simulation.

## Introduction

Driving simulators are more and more frequently used in fields such as the driving psychology, ergonomics, training. To immerse subjects during experiments and thus obtain results which match actual situation, the driving simulator must reproduce movements close to those of the vehicles. Generally, it is based on upon a traffic simulator which aims to provide a realistic traffic and to allow working with many parameters such as the environment topology, the traffic density, the different types of vehicles.

There exist many approaches to simulate the traffic, the major ones being mathematical and behavioural. The mathematical approach provides traffic

from differential equations of flow [7]. Unfortunately in this approach, the simulated vehicles are similar, we cannot distinguish neither vehicles types nor driver types. Whereas, in the behavioural approach, the traffic is created from actions and interactions of the actors [4]. We are situated at the individual level. This approach has the advantage of allowing many types of goals: to mesure or to act at the macroscopic level (road density) or at the microscopic level (influence of the individual characteristics). The macroscopic goal focuses on the traffic seen as vehicles flows, and looks at physical datas such as density and average speed on the differents lanes. The microscopic goal deals individually with the differents entities, in particular their actions, their interactions and driver features. We work in the framework of the traffic simulation with a behavioural approach and our goal is to observe a vehicle type. In this work, we consider that a driver and his vehicle are the same entity.

There exist many traffic simulations, such as Microsimulation road traffic[3], TSIS-CORSIM[4], PARAMICS ou AIMSUN. In most simulations, vehicles move on a rail which is common to all the vehicles, laid on the road (generally one rail per lane). The vehicles pass from one rail to another,e.g. in the case of overtaking. All vehicles work in the same way, notably with the same movings. The distinction car/truck/motorcycle is done only at the rendering level. But in reality, we observe typical moving for the motorcycles such as driving along (see figure 1(a)) and dodging (see figure 1(b)).

Definition: DRIVING ALONG:
*When a two-wheels drives between two queues of cars (in the same direction), with a speed higher than those of the flow of the two queues and without taking a lane delimited by the road marking, we say that the motorcycle is* driving along *the queues.*

Definition: DODGING:
*We call* dodging *the action of changing lane with passing between two vehicles of the same lane.*

These movings exist because of the motorcycles properties (driveability, size). They appear to be atypical only because the road is not structured for this kind of transport.

We note that the solution of the static rails (one per lane) cannot work for the motorcycles. We support that motorcycles must have specific environment. For this, the motorcyclist needs to have a way to structure his environment. In the

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[3] http://vwisb7.vkw.tu-dresden.de/treiber/MicroApplet/
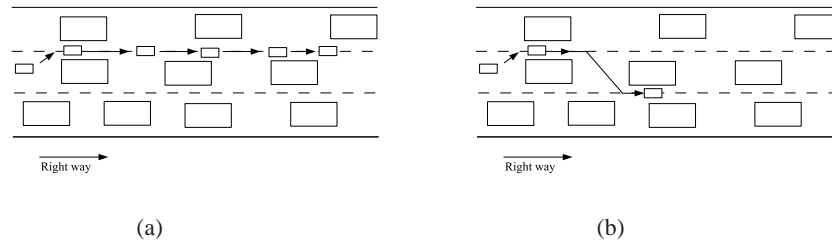[4] http://mctrans.ce.ufl.edu/featured/tsis

**Fig. 1.** (a) The motorcycle drives along a car queue. (b) The motorcycle dodges between cars.

simulation, this is made by a calculation by the agent of his lanes of circulation: the virtual lanes.

In this paper, we express the motorcycles specificities compared to the others vehicles. We expose some characteristics of our trafic simulation. Then, we precise our conception of the virtual lanes and we explain the algorithm of lane choice. To validate our approach, we integrate our model to a trafic simulation: ARCHISIM. Thus, we observe the driving along and the dodging movements by emergence and we compare real data with they simulation results.

## 1   Motorcycles specificities

Motorcycles provide a travel mode more and more valued in urban areas. In spite of their advantages, they are considered as vulnerable users because of their lack of protection and of visibility. The victims rate is constantly growing [5], however few researches has been made to better understand motorcyclists behaviour. On the one hand, at accidentology level, some papers explain that most of motorcycles-cars collisions are due to the fact that motorcycles are not perceived as dangerous by the others users, or not perceived at all [14]. Car drivers do not expect to see a motorcyclist where they drive, thus when they look for visual informations, e.g. to take a lane changing decision, even if they see the motorcycle they do not take it into account in their decision. Their presence is thus ignored. On the other hand, Minh's works ([10] and [9]) concerning the motorcycles give us some mathematics data, but no rules dictating the moving. No study explains why motorcycles have, in France, differents moving compare to the others vehicles. These moving such as the *driving along* (see figure 1(a)) and the *dodging* (see figure 1(b)), are atypical movings compared to the others vehicles.

Even if motorcycles and cars have differents movings, their drivers have the same desire, i.e. minimize the constraints during movements, the ideal being to drive alone on the road. The behaviour (in the sense of "moving and decision

taking") model of the car driver cannot be applied to the motorcycles because of their mobility.

Because of their specifics moving, motorcycles are seldom found in existing traffic simulation. PARAMICS[5] (Quadstone Paramics) or AIMSUN[6] (TTSiM) incorporate in their simulation several vehicles such as trucks, bus, cars, but no motorcycles. VISSIM simulation[7] (PTV) allows to add to the simulation some bikes. Unfortunately the moving conditions of the motorcycles do not seem realistic because they are not mixed with the traffic, they always drive on a reserved lane, separated from the road by a central reserve. There is no interaction between motorcycles and cars, they have both separated roads.

We are interested in the driving task. It splits up, for Michon [8], into three parts:

1. the strategic part: itinerary choice;
2. the tactical part: manœuvre choice;
3. the operational part: manœuvre execution.

The strategic part cannot induce such behaviours (the itinerary choice and the way of driving are not likely dependent). The operational part intervenes in the moving but only when the moving decision has been taken. We propose to dismiss these two parts and to focus on the tactical aspect: "why, and thanks to what informations, does a user take a decision rather than another?". We are interested in the decisions taking as well as in the way the driver see the environment.

To obtain realistics moving, the perception of the environment must be as rich as possible. In our opinion, the road marking does not define a space for the motorcycles. We note that the width and the type of the road are defined in relation with the traffic type and with the vehicles types in this traffic. We observe that a little used country road is less wide (and often has only one lane in both direction) than a road in center town. While looking at figure 1, we understand that the road marking is taken into account when the motorcyclist takes his decision. We start with the hypothesis that a major difference between cars moving and motorcycles moving is the road representation. The main question in this work is: Which representation do they have of their environment?

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[5] http://www.paramics ollnline.com/demos/demos_movies.htm

[6] http://www.ttsim.com/Produits/aimsun.htm

[7] http://www.francais.ptv.de/cgi-bin/traffic/traf_vissim.pl

## 2 Traffic simulation characteristics

Before explaining the virtual lanes, we briefly present the traffic simulation structure as well as the main characteristics of the differents actors of this simulation.

We split up the simulation into two parts. On the one hand we have the environment (constitued by roads and objects) and, on the other hand, the actors. This decomposition and the characteristics are examples, but they sum up quite well what a traffic simulation contains *in general*. The actors have some caracteristics like speed, position, itinerary, desired speed. These elements are useful in lanes calculation and in the algorithm which we propose. They constitute the knowledge which we allowed ourselves to reason and which we use in this paper.

The environment is composed of roads and objects. The road is symbolized by an single axis which is anywhere on this road (in the middle, to the left side, etc.) parallel to the road sides. When the mobiles move on a road, they are located about this axis (see figure 2). The coordinates of the objects and of the mobiles are expressed in road (r), kilometer point (pk), distance from the axis (lane) and orientation angle (heading) (see figure 2).
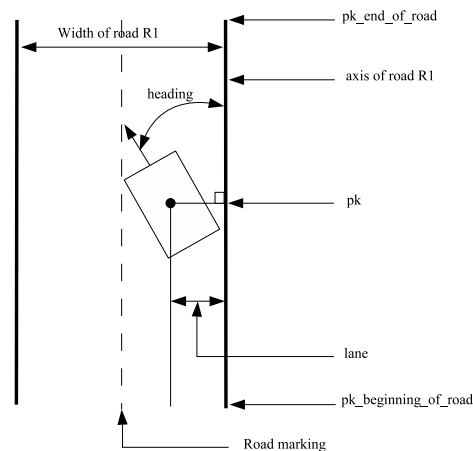


**Fig. 2.** Vehicles coordinates signification and some road characteristics.

The objects of the simulation (traffic lights, roadsigns, etc.) are like passive actors of the simulation. They give information to actors about the authorized speed, the proximity of a danger, the possibility to pass the intersection. They

do not act on the environment, do not perceive their environment, do not take decisions. We will not address this question in our paper. The simulation actors are trucks, bus, cars, pedestrians. A motorcycle has the same characteristics as the others. It has, among others, a position (pk, lane, road, heading), a "seen-objects" list which groups together objects and actors seen by the actor. This list does not contain all the objects and the actors of the simulation, only those seen by the actors in their halo of vision. This halo of vision splits up into many parts according to the sides and the proximity. Thus we have right-left-front-back for the sides, and very near-near-distant for the proximity, as explained in [6] and illustred by figure 3. Concerning the differents characteristics of the actors, some can be known by the others actors, some do not. Thus a motorcyclist knows the vehicle type present in his halo but does not know his itinerary. With this halo of vision and this characteristics distinction, actors have a limited vision of their environment.

| Left pressure 2 | Very near lateral left 2 | | Near lateral left 2 | Distant lateral left 2 |
|---|---|---|---|---|
| Left pressure 1 | Very near lateral left 1 | | Near lateral left 1 | Distant lateral left 1 |
| Back | Vehicle | Very near | Near | Distant |
| Right pressure 1 | Very near lateral right 1 | | Near lateral right 1 | Distant lateral right 1 |
| Right pressure 2 | Very near lateral right 2 | | Near lateral right 2 | Distant lateral right 2 |

**Fig. 3.** Representation of the different parts of the vision halo.

Some actors characteristics hide some subtilities. We can cite *Vehicule_type*. Each actor has a type and with this type we have supplementary informations about the actor. In this precise case, we have the width, the length, the height, the car power, etc.

## 3   Virtual lanes

As previously said, motorcyclists and car drivers both want to minimize their constraints but with differents capacities (manoe uvrability, size). Thus for the same situation, e.g. move on a congested road, car drivers must "put up with the delay" or try to change their lane to drive on the lane where the traffic is more rapid, whereas motorcyclists drive along cars queues. We notice that they define space for theirselves and create circulation corridors like [12] to drive along cars queues. In [10], the authors suggest to cut up the road according to car width. But in this article, the corridors are just fixed by cutting up (with the

same width) the lanes defined by the road marking. This solution seems too rigid because it does not take into account the road occupation by the others vehicles. The definition of the free space must be dynamic because the cars move, thus the occupation and the free space change.
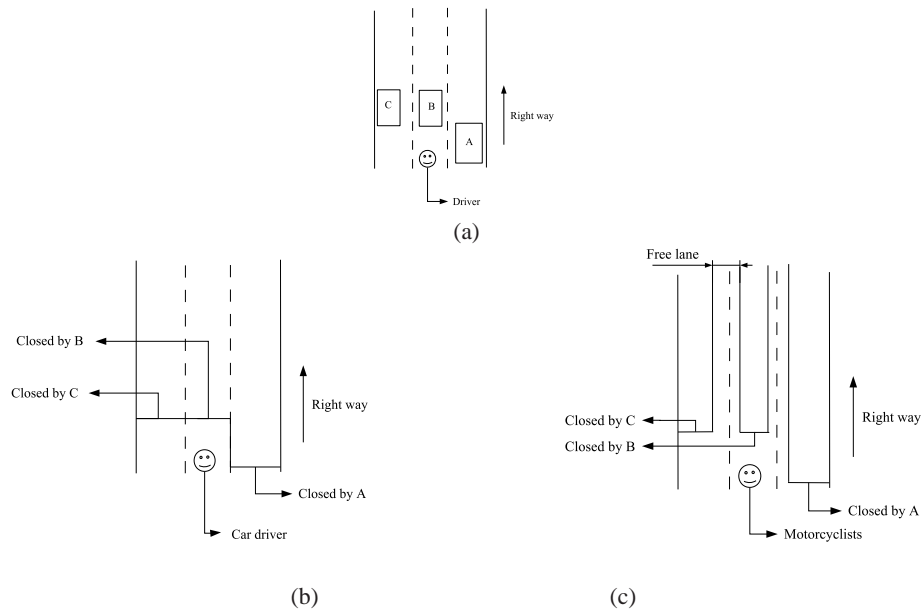


**Fig. 4.** (a) Congested road where a driver must imagine the space. (b) Point of view of a car driver about the congested road. (c) Point of view of a motorcyclist about the congested road.

Figure 4(a) represents a road with three lanes. This situation is close from a highway situation where the passage is totaly blocked, as we can see on figure 4(b). But if we perceive the road like a motocyclist, we have the representation shown in figure 4(c). We distinguish the spaces closed by the vehicles, and the free spaces.

To represent these free corridors, we define an other type of lane: the virtual lanes. They have the attribute "virtual" because they are not physically defined contrary to the physical lanes, defined by the road marking.

Definition: VIRTUAL LANES:
*Circulation corridors built by the roadsides and vehicles present in the halo of vision of the actor.*

For example, in figure 5, the lane [L(b);R(c)] is defined in relation to the **L**eft side of the vehicle b (function L) and to the **R**ight side of the vehicle c (function R), L(Road) (resp. R(Road)) stands for the roadside on the left (resp. right) of the road.
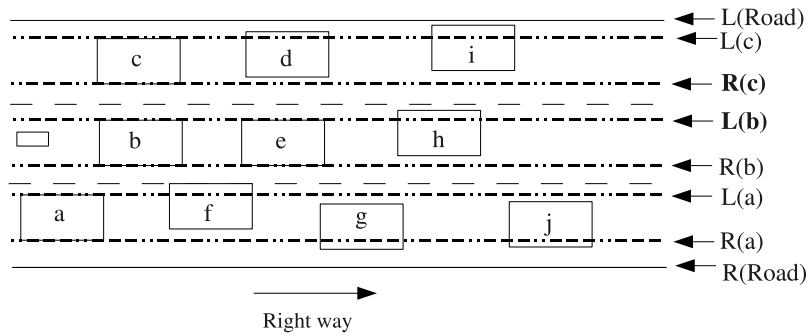


**Fig. 5.** Example of lanes defined in relation to the others users. L(x) is a function which gives the position of the left side of the vehicle x, R(x) for the right side of the vehicle x. L(Road) (resp. R(Road)) stands for the roadside on the left (resp. right) of the road.

We can note that we don't treated the problem of the contra-flow traffic. The motorcyclist calculate his virtual lanes in his way of driving.

Among the vehicles present in the field of vision, we eliminate some: those behind and those are too far away. In fact, to take all the vehicles into account for the lanes calculation is:

– expensive because some vehicles are useless in the lane choice for a precise situation, e.g. in figure 5, vehicle j is useless at the present instant because it is too far, we prefer to concentrate on vehicles a, b and c;
– non-productive because in some cases a distant vehicle closes a virtual lane, free until now, and prevents a driver from moving forward. For example in figure 5, vehicle h closes the lane [L(b);R(c)], the motorcyclist can choose another lane (lane [R(b);L(a)]), more risky than lane [L(b);R(c)].

For these reasons, the virtual lanes calculation is done with the closest vehicles on the front of the motorcycle.

This calculation is possible thanks to the informations the motorcyclist has concerning what around him. This driver knows his environment, i.e. he knows:

– the characteristics of the actors close to him, such as their positions, the state of the indicators (on/off) if it is a vehicle (brakes, turn signals);

– nearby objects: road signs, traffic lights, etc.;
– the road characteristics: width, road type, etc.

To calculate the lanes, the driver only need to know the road width, the position of the vehicles in front of him on the same road and the type of these vehicles. The vehicle type is usefull to know the width and the length of the vehicle. Thanks to these calculations, the motorcyclist obtains a cutting of the road with free "bands" and occupied "bands" (7 virtual lanes on the figure 5). This results in two types of virtual lanes: forbidden virtual lanes and authorized virtual lanes.

Definition: FORBIDDEN LANES:
*Virtual lanes that a motorcyclist must avoid to take. A motorcyclist can take it if the time spent on this lane is short and/or if no vehicle is on his trajectory. These lanes are defined thanks to the vehicles.*

Definition: AUTHORIZED LANES:
*Virtual lanes that a motorcyclist can take. These lanes are defined thanks to the free space on the road, between vehicles and road sides.*

The forbidden virtual lanes are those where a vehicle is ([R(a);L(a)] in figure 5). The authorized virtual lanes are those where the passage is possible (between two vehicles like [R(b);L(a)] or between a roadside and a vehicle like [L(Road);L(c)]). Then, a sort is organised among the virtuals lanes because it can happen that an authorized virtual lane has insufficient width (in the case of a vehicle very close to the roadside). This lane will pass to forbidden lane, it is the case for lane [L(Road);L(c)]. We define an insufficient width according to motorcycle size and a security distance.

This simple calculation is not sufficient to assert a coherent moving. A motorcyclist has a representation of his environment, he must choose now what lane he takes.

## 4   Virtual lane choice

The calculated lanes allow the simulated motorcycles to represent the space where they can move. A lane must be choosen now. Several matters arise:

– On which criteria is the choice based?
– How to avoid the oscillations?

When we talk about oscillations, we are not talking about the traffic flow which can oscillate between a road A and a road B according to hours or trafic density [11]. We talk here about the oscillations phenomenon from an iteration to the other. This phenomenon is usual in behavioural simulations. In fact, the choice

of a lane circulation must be invariant according to the vehicle position, i.e. whatever the position and for a fixed context the driver's choice must be invariant.
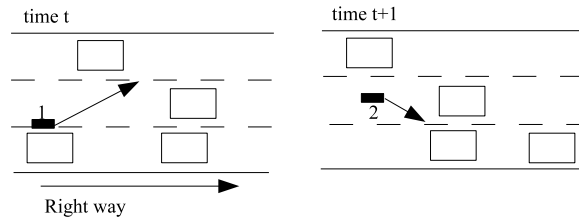


**Fig. 6.** Oscillation phenomenon example. At time t, the motorcycle is in position 1 and wants to go on his left. At time t+1, he is in position 2 and wants to be on his right. He comes again in position 1, where he wants to go on his left, etc.

As indicated in figure 6, the motorcycle oscillates between two decisions according to his position. In position 1, he wants to go on his left, he goes. At the next time step, he is in position 2 and wants to go on his right. He go back to the lane occupied when he was in position 1, etc. The problem is not to change his decision but to change rapidly, the frequency of the oscillations must be controlled. In brief, we need to find the good combination of obstination (to avoid oscillations, the motorcycle must keep his decision enough time) and safety. The motorcycle must understand that his choice need to be changed. But this situation will often happen with a change of context. We define that, for a same context, the motorcycle will take the same decision. But the fact that the cars move, that the motorcycle changes lane are not context change criteria. Whereas an indicator, or the taking into account of another vehicle, means that the context changes.

The lanes choice criteria are numerous and various. We start with preferences hypothesis based on some observations in France:

– passing on the left;
– not to be near the roadside;
– drive on wide lanes;
– a speed close to a desired speed.

The calculated virtual lanes have some characteristics such as width, type (authorized / forbidden) and speed. The speed of a lane is calculated thanks to speeds of the vehicles forming this lane. A forbidden lane has a null speed, an authorized lane has for speed the average of the speeds of the vehicles present

on the adjacent lanes, with for the road side a null speed. Thus for a lane defined by the road side and a vehicle driving at 80km/h, the lane between both (if it is authorized) has a speed of 40km/h. The road side has a null speed to prevent motorcycles from being near the road side if the lane is not wide enought to be safe. Thanks to these speeds, we obtain a speed-width coefficient that we use in the lane change algorithm.

The motorcyclist chooses his lane following an algorithm using hypothesis, lanes characteristics and driver's vision. This algorithm is built on a subsumption architecture [1]. It is presented in figure 7 (the rules with greatest priority are on the top, those with less priority on the bottom).
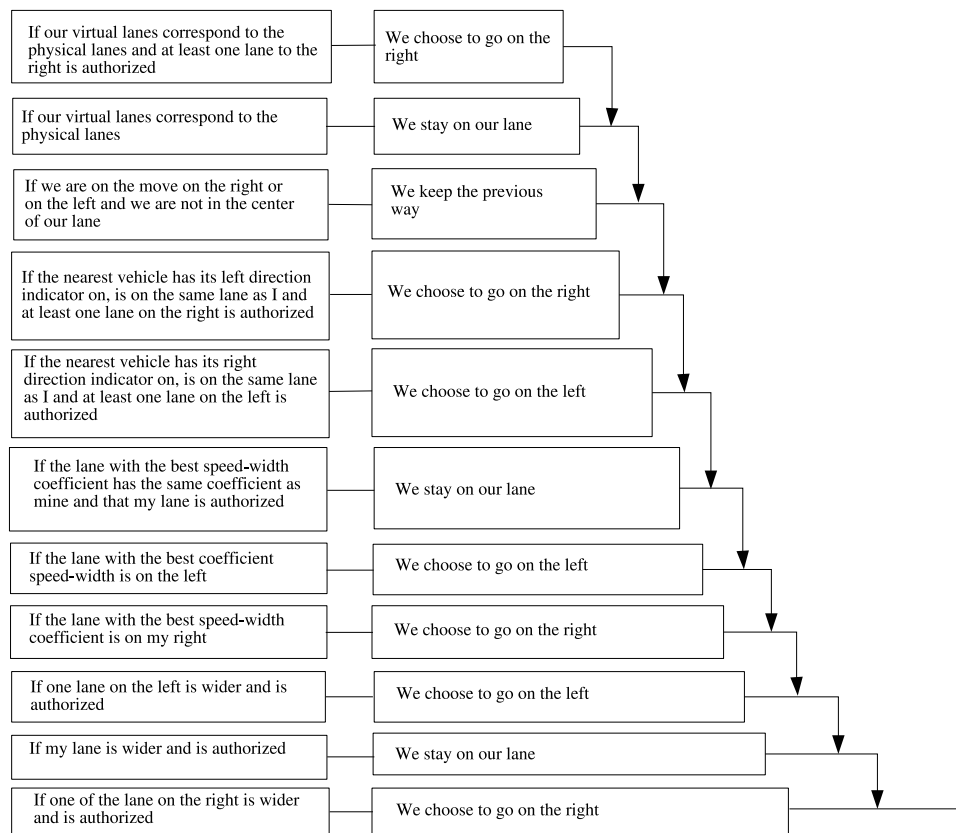


**Fig. 7.** Algorithm for the lane choice using a subsumption architecture (the rules with greatest priority are on the top, those with less priority on the bottom).

To sum up the algorithm, we can say we have four cases:

- the choosen lane is a physical lane;
- the vehicle in front of the motorcycle changes his lane;
- the choice is based on the speed-width coefficient;
- the wider lane is choosen.

Of course this decomposition hides another decomposition according to the side. As indicated before, the halo is divided into several parts, like near lateral right 1 and near lateral right 2. This implies that we do not only take into account at the adjacents lanes, but also the actual lane, the two adjacents lanes on the right and the two adjacents lanes on the right. To consider only the adjacents would be very restrictive, as proven in [3]. If a motorcycle takes a lane (which be calculated because of vehicles presences), he has for adjacents lanes, the lanes occupied by vehicles, thus these lanes are forbidden. The motorcyclist cannot change his lane. He only changes his lane, when his current was forbidden and his choice can only be right lane or left lane. Unfortunaly, there are some cases where a lane is forbidden whereas the left and the right lanes are both forbidden (when vehicles are too close). If we only consider the lanes which are directly adjacent, the motorcycle is blocked without the possibility to choose. To have a traffic simulation close to the reality, we give to the motorcycles the possibility to go to two lanes on the right and on the left. This explains the expression "at least one lane on the right" in figure 7.

As indicated before, we start with the above hypothesis (only valide in France) and we lay down that if nothing blocks a motorcycle, he uses the road marking. This algorithm is not full but it proposes rules that can be easily modified to incorporate some nuances according to the driver's type, his experience and according to future studies. Indeed, no study gives solution either in taking decision or in traffic (journey time, impact of motorcycles on the traffic, average speed, etc.) to understand the motorcyclists behaviour. Nevertheless, our algorithm offers some lane selection criteria, which can be discussed but which give, from our observations, some satisfying results.

## 5 Results

The models previously described were implemented in an existing traffic simulation: ARCHISIM. These models are in the process of validation.

### 5.1 Implementation

ARCHISIM is a traffic simulation which uses the behavioural approach, its implementation follows the multi-agent concepts. The drivers of the simulated vehicles are agents. They function according to three main process: perception,

decision and action. The behaviour of agents is defined thanks to the motives of the decision taking of the actual drivers.

The aim of ARCHISIM is to develop traffic simulations "individuals" centered based on the behaviour of actual drivers [4]. The driver's model on which ARCHISIM is based relies on the works of F. Saad [13]. The traffic emerges from the individual actions and interactions between various actors. This model was validated for car-following (on motorway) and merging ([6], [2]).

The simulation is splited up in time steps. At every time step, each agent present in the simulation sends a query to the vision server. This query contains his current visible state, i.e. his position, his speed, state of the indicators, etc. The query concerns the elements which each agent can perceive thanks to its halo of vision. The vision server waits to receive all the queries to update the database representing the network. Then it determines and sends to each agent the elements it can perceive. Each agent receives from the vision server the list of elements presents in its environment. These informations are used by each agent to update its knowledge and to adapt its behaviour.

The vision server is an interface between the database, which represents the network, and the agents, allowing to provide them with what they can perceive. Using this mechanism, the agents do not have to calculate what they really can see, as in the real world. It is important to note that this vision server has no intelligence, it only "distributes" information to the agents, it does not interpret anything and it does not supervise anything.

As a conclusion, the agents are situated (they are located on the road network) and they do not know everything (they only perceive what is in their environment). The operation mode of ARCHISIM is distributed and parallel.

To represent the virtual lanes, we choose an array of lanes[8]. These lanes have a width (integer) and a type (character).

```
VIRTUAL_LANE =
   RECORD
      width = INTEGER;
      type = CHAR;
   END;
VIRTUAL_LANES = ARRAY [0..nbMaxLanes] OF VIRTUAL_LANE;
```

We give to each virtual lanes a width and a type calculated by the model of lane calculation. The differents steps of its implementation are to find the impeding vehicle and to calculate the free spaces between them.

After the calculation of his lanes, the driver chooses a lane. The implementation is extremely close to the model because of its architecture. We do not explain in detail here its implementation which, amounts to a succession of:

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[8] The language used in this project is Modula2 (close to Ada and Pascal)

```
IF property1
   THEN choice1
   ELSE IF property2
      THEN choice2
...
```

To resume, if a motorcyclist drives on a road and he is alone, he drives on the right lane (cases 1 and 2 in the figure 7). If he is not alone, there is at least one impeding vehicle : he calculates his virtual lanes and chooses the best one following the algorithm : looking at a first time the nearest lane on the right and on the left (right 1 and left 1 in the figure 3) and if they are both forbidden the distant lane (right 2 and left 2 in the figure 3).

### 5.2 Validation

There are many validation methods of traffic simulations. We can cite : (a) the comparison with real values about the flow, the average speed of vehicles, the average speed at certain points, the time to travel, etc. (b) the opinion of psychologists or domain experts about the traffic, the behaviours, etc. (c) the opinion of users during experiments.

In the case of cars, some studies give the average speeds, the heaviness, the road occupation, etc. on itineraries thanks to sensors lay down the road and/or with equipped vehicles. Unfortunately, in the case of motorcycles, officials studies about the average speed or their time to travel do not exist. We are not able to validate our model, except by observing the motocycles usual moving. Nevertheless, we support that we have a base of reflexion which can be expand thanks to futures studies.

An ADEME[9] study aimed to compare the consumption and the pollutant emmissions of motorcycles and cars on a journey of 31 kilometers (19 miles) with departemental roads, national roads and highway. The method consisted in making simultaneous recording, on roads, in "framed" conditions on a scooter 125 cm$^3$, a motorcycle of 600 cm$^3$ and an "urban" car. The motorcyclists were experienced and often used a powered two-wheelers. Their driving must be rational, i.e. with respect for the speed limits and for the motorcyclists the driving along cars queues were allowed if the cars queues were idling. The type of the trip is home-work from the suburbs of Paris to the center of Paris. These records provide datas such as the average speed, the travel time and the number of stops. The average datas are summarized in table 1.

The comparison with the real data validates the general traffic, but not the individual behaviours. Thus we need several validation methods. We could either have the motorcyclists have a look at our simulations or film drivers on an

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[9] French Environment and Energy Management Agency

| vehicle type | travel time | average speed | number of stops |
|---|---|---|---|
| Car | 1h27min10sec | 21.18 km/h | 78 |
| Motorcycle | 44min23sec | 42.58 km/h | 23 |

**Table 1.** Real mesures on a route of 31 kilometers: travel time, average speeds and numbers of stops according to the vehicle type.

itinerary and compare these movies with our simulations. For the time being, we observe the atypical behaviours as illustrated by the screenshots (see figure 8) and we obtain the experimental values resumed in table 2.
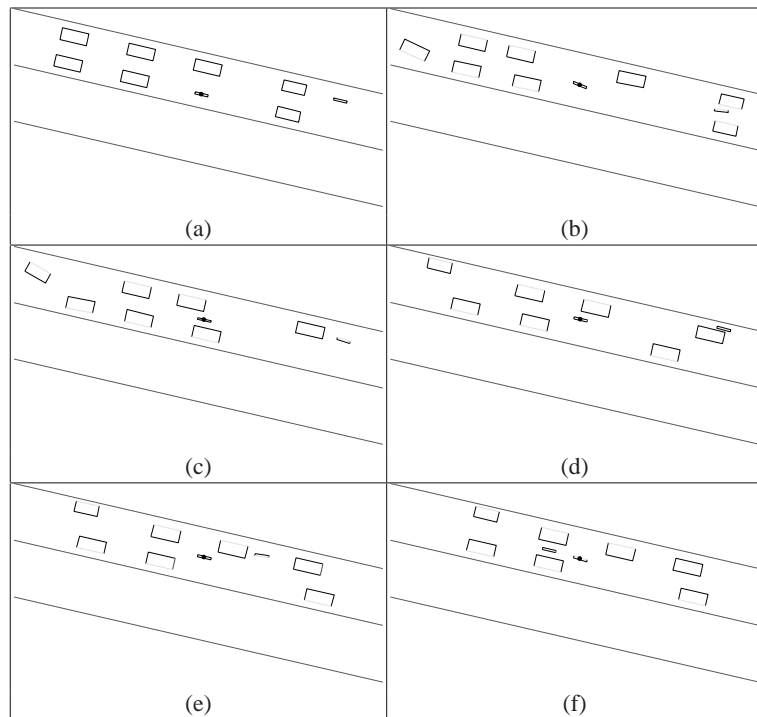


**Fig. 8.** The differents steps of a driving along and a dodging. One motorcycle (on the center, with the black point in it) drives along car queues. The other motorcycle passes a car on the left (b), then passes a car on the right (d) and drives along (f).

| vehicle type | travel time | average speed | number of stops |
|---|---|---|---|
| Car | 57min06sec | 24.29 km/h | 77 |
| Motorcycle | 32min32sec | 42.64 km/h | 31 |

**Table 2.** Experimental measurement on a route of 31 kilometers concerning the travel time; the average speeds and the number of stops according to the vehicle type.

## Conclusion

The driving simulators are more and more used because they enable to have results in more secures conditions (driving with fog, in hypovigilance or under medical treatments). But to have a subject, in the case of a psychological experiment, which drives as close to the reality as possible, he must be totally immersed. One of the immersion factors is the traffic simulation in which the subject will "drive". But the motorcyclists are poorly represented in these simulations, because of the complexity of their moving. We start with the hypothesis that these movings are due to the fact that the motorcyclists do not perceive the road like the other users. We give them a way to perceive the road which enable them to take "easily" a decision. We call this new structuration the virtual lanes. These virtual lanes added to a lane choice algorithm based on a subsumption architecture allow the motocycles in our simulation to move about in the traffic. Moreover, we observe the specifics behaviours of the motorcycles, such as dodging and driving along.

Some lane choice criteria can easily be integrated to the algorithm, such as the lanes length, the danger they represent, the number of lane changing, driver experience, stress due to the other drivers, etc.

The validation is an important step in simulation, we need a validation for the individual level to check that behaviours obtained are always close to those observable. This is the case for dodging and driving along. Furthermore, thanks to the ADEME data such as the travel time, the average speeds and the number of stops, we validate our models.

The road is now open to study the motorcycles impact on the traffic, the differents types of characters of motorcyclists.

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