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Architecture and Ontological Modelling for Assisted Driving and Interaction

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Abstract

Various proprietary vehicular technologies have been integrated on commercial vehicles. Most of these assistance systems, however, are systems of perception, of alert or of very simple commands which are attached to one or two sensors only. There is not even a support with regards to information involving environmental context. There is not even use of the user profile and actual state of the driver. There is not even sharing of modalities (such as voice synthesis for example) because the products and software of each OEM (original equipment manufacturer) or designer are often closed to proprietary constraints. These are the weaknesses that our work would like to address. We take a traffic situation, consider the traffic rules, and consider the context of the driver, the car and the environment and provide guidance to the driver. Our aim is to provide assistance to prevent traffic accident. We begin with "Turn Left in an intersection" situation and progress forward. An architectural design has already been developed to cover all kinds of traffic conditions. Ontology is used to represent driving modelling and road environment. Our aim is to contribute to the body of knowledge in the domain of prevention of vehicular traffic accident.

Keywords

Ontology, Vehicular technology, Intelligent mobility, System modelling.

1. Introduction

There are various situations that can be described as disability situations for many drivers. This situation is the result of various factors. Thus, the driver may find constraints with regards to his expertise or capacity, whether he/she is in the learning stage, an elderly, a person with disability or normal but fatigued or someone not familiar with the area. Such driver may experience difficulties that could have significant impact on his driving. Similarly, when driving a vehicle that is equipped with a set of support, it may happen that one will face complex situations that are not quite easy to handle. They include, for example, carefully not reaching a tollgate after a long trip with an accelerator control activated or simply driving too fast after leaving an expressway.

The driver must be assisted or guided in the situations cited above. This leads us to the main objective of this study: to support a vehicle driver with an aim of preventing the occurrence of an accident. The proposed approach is to study a particular situation first and afterwards specify the appropriate assistance. We chose the road intersection with the car going to turn left. In this situation, the driver is required to perform two tasks. The driver needs to monitor other vehicles in different directions while assuring that he himself performs proper driving behaviour. "Left turning" is often a dangerous situation. This specific case will serve as the baseline to specify our proposals. On this basis, a generalization for different situations as well as different driver profiles will be as well considered.

2. Review of the State of the Art

We investigated various types of driver assistance provided by different vehicle manufacturers. Formerly reserved for top-of-the-range vehicles, a lot of assistance is now available on the vehicles in large series; others are optional and very costly. The table found in this section presents a set of technologies for driver assistance available in the market or in the course of research (international or European projects). With this state-of-the-art study, we have

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decided to deal more particularly with assistive technologies associated with our specimen traffic event-turning left in an intersection [1]. See Figure 1.

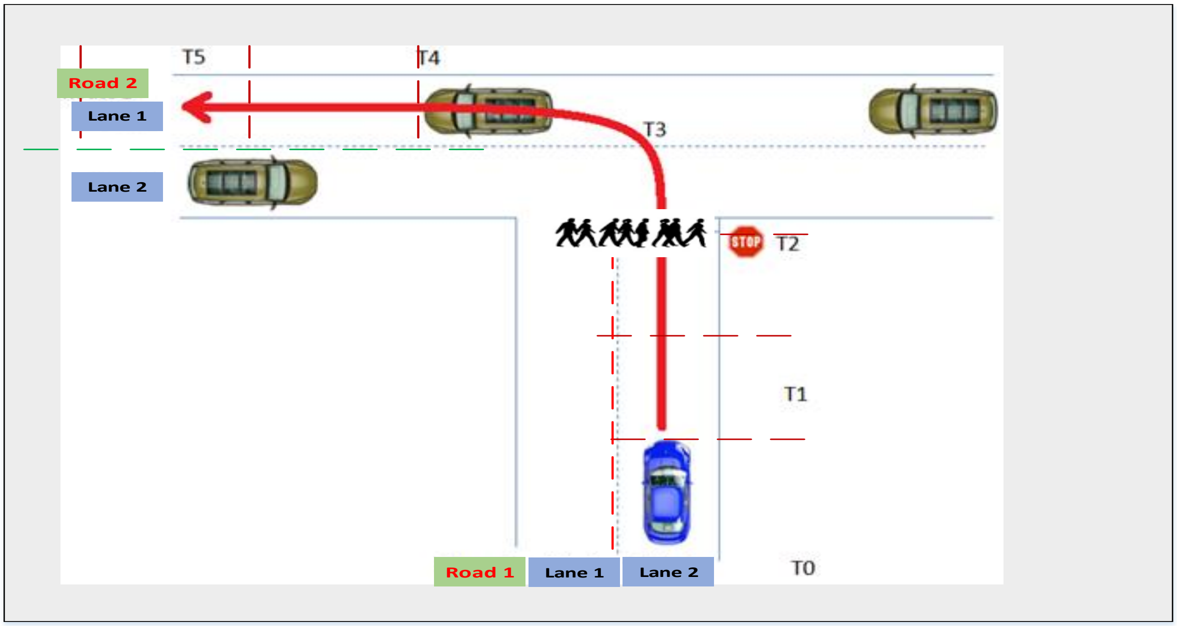

Figure 1: Traffic event of interest in this paper – Vehicle turning left

2.1 Brake assistance and Distance Assessment

In this framework, the adaptive acceleration control and collision avoidance systems are important in terms of managing obstacles in front of the vehicle before the vehicle arrive to a stop. This case may also be used for controlling acceleration prior to the arrival in a toll station.

The brake assistance is essential prior to arrival at a stop especially in cases where the driver is distracted. In some emergency situations, the driver does not usually step on the brake pedal as often and as strong as he should do. Hence, when the system detects a transition of driver abnormally changing from the accelerator pedal to the brake pedal, the system should decide to put the maximum brake pressure possible.

In 2003, Daimler-Benz has significantly improved its system, called BAS Plus [2], by pairing it with radar for distance management. The objective was to avoid collision in the rear of the car or to lessen the impact of collision. In this system, with the following car equipped with BAS Plus, the distance and the approaching speed between the two vehicles are constantly measured. In the event that their speed difference becomes too high, a visual alarm is triggered and an action on the brake activates the emergency brake assistance.

2.2 Intelligent Speed Assistant

Thanks to the digital road map of the geo-positioning systems or to the optical recognition of road signs, the speed wizard (ISA or Intelligent Speed Assistance) is generally well informed of the maximum speed in a specific part of the road on which a driver is situated. It may, in the event that the driver exceeds this speed, actuate an alarm (passive version) or automatically reduce the speed (active version). The ISA contributes to road safety, allowing drivers to drive more relaxed. The anti-collision system warns driver of imminence of a collision and may prevent it. It is activated when someone approaches too close to a preceding vehicle or when there is an obstacle on the road.

Some systems intervene actively: if the risk of collision continues to increase and that the alarm signal remains without effect, the assistance system triggers an emergency brake. Some systems capable of identifying the risks of collision with pedestrians and cyclists have already been out in the market. The adaptive speed regulator (ACC or Adaptive Cruise Control) take notes of the vehicle in front and keeps a good distance for security purposes.

Twenty-one, twenty-two … the rule of two seconds is not always easy to enforce, particularly on the highway when everyone brakes, accelerates, and changes lane. The acceleration control is in charge of this mission. When the safety distance becomes insufficient, the system intervenes: depending on the manufacturer's version, the speed regulator automatically brakes the car or warns the driver until the distance becomes sufficient again.

2.3 The Crossing Assistant

The Crossing Assistance "Go No Go": The BMW's experimental system prevents the driver from pass turning to the left by cutting off another road user. BMW develops a system to assist in crossing intersection [3]. For the time being, this system treats only the case where the driver is trying to turn left by passing through a lane for vehicles in the opposite direction. The system uses the data from the GPS and a camera to locate the road intersection and automatically brakes the car when a vehicle (car, truck or motorcycle) arrives from the opposite direction. This is made possible through the use of three laser radars. The device operates only up to 10 km/h.

2.4 Natural Voice Assistant

Natural Voice Guide: The natural voice guide is a means of danger prevention; the voice support is for a better preparation and attention before and during going to the crossing zone. With a robotic voice telling the driver to prepare to turn left in 400 meters, such scheme is not very enticing to a lot of drivers. However, with natural voice associated with a navigation system, preparing to turn left after a mark becomes more interesting. It thus improves the current GPS and could be triggered in some situations depending on the result of the fusion of information (GPS, road, intra-vehicular, medical and other) and provides assistance to the distracted or sick driver or to one who does not comply with certain rules of good road conduct. Siri is an assistance voice system integrated in Apple phones. This interests General Motors which just announced that it would integrate it into some of its vehicles.

To start with, it would have Chevrolet Spark and Sonic LZ and RS in the United States which will have the personal assistant system. Here, the driver just keeps eyes on the road and both hands on the steering wheel because he activates different functionalities of his iPhone through voice. In France, the manufacturer provides the integration of such system on Aveo and Cruz in 2013.

[4] announced that its Assistance Wizard will work from the information system MyLink, which equips several models of the Chevrolet series, and that it is necessary to have an iPhone compatible with operating system IOS 6. The drivers equipped with the system may therefore use their iPhone in "eyes free" mode which will enable them to activate all the features of their phone through voice. All the driver has to do is to connect to the car's Bluetooth and to activate the key to voice synthesis from the steering wheel. For future users, making phone calls, listening to music and transitioning music source between radio and an iTunes file, listening to and even dictating texts, all these and more will be activated using voice commands. Hence, there is no doubt that these options will delight the many fans of the Apple technology. It is, however, worth asking if this new gadget will not be a distraction to the driver's vigilance given the fact that the IPhone once connected to the system will not have a lit screen which would enable the driver to focus his attention on the road.

2.5 Urban Intelligent Assistant

Urban Intelligent Assist is another ongoing research project by Audi [5, 6]. The project aims at finding technologies that can help reduce traffic congestion, improve safety, and reduce stress on drivers. According to Mario Tippelhoffer, chief engineer of Audi, "We are developing applets for smartphone which help you plan your trips before you enter in your vehicle". The team of USC (University of Southern California, USA) collects data from multiple sources of predictive information for the drivers using the suite of Audi driver center applications for urban navigation.

The application Fusion Assist is a new application designed to help drivers to get the speed and the timetable needed to get smoothly into the surrounding traffic, giving them a target speed on the instrument panel and the green LEDs in the mirror telling them that it is time to merge into the traffic.

[1] https://www.apple.com/ca/ios/siri/

To do this, the system acquires the necessary information on the vehicle's surrounding using a combination of video cameras and radar, said Tippelhofer. "We have some really sophisticated sensors which can monitor 360 degrees around the vehicle," he said. The application Attention Guard focuses on the problem of driver distraction, using cameras which monitors the driver and gives alert to regain driver's attention if the same is not focused on driving. The aim is to bring the driver back to his driving task.

2.6 Observation and Discussion

Most of the technologies cited above are important. However, most of the assistance systems are systems of perception, of alert or of very simple commands which are attached to one or two sensors only. There is not even a use of information concerning environmental context. There is not even use of the user profile and its current status. There is no even sharing of modalities (such as voice synthesis for example) because the products and software of each OEM or designer are often closed to proprietary constraints. There is no checking vis-à-vis of the Highway Code (ideal driving) to avoid putting the driver in danger. Some of these weaknesses will be addressed by our work. We intend to consider the context of the driver, of the vehicle and of the environment [7] in determining the kind of assistance we will provide the vehicular driver.

Table 1: Types of driver assistance provided by different vehicle manufacturers

Audience	Technology	Manufacturers
Park	Reversing camera, Ultrasound	All
Emergency Braking	Pedal sensor	Daimler-Benz, Renault
Anti-collision System	Camera, Radar	Honda, VW, Ford, Fiat
Cruise Control (Adaptive)	Butterfly + GPS + Traffic	BMW, Mercedes, Renault
Alert line crossing	Infrared camera	PSA, LandRover
Night vision / Headlights/ Animals detection	Night camera, Headlights	Mercedes, PSA
Detection of drowsiness	Driver's vision, Ultrasound	General Motors, PSA
Emergency call (smartApp)	Phone	Audi
Side monitoring	Camera, ultrasound	LandRover
Intersection (case lanes prohibition)	Radar, Camera, GPS	BMW
Insertion into the traffic	GPS, Radar, Camera	Audi
Voice guide (natural language)	GPS, Sensors, Voice synthesis	Audi, General Motors(Apple SIRI)

3. The Proposed Architecture Assistance

We propose to model and develop all or part of the following architecture (see Figure 2). The architectural model proposed in this study corresponds to a multi-audience approach. The input and output modalities (see components represented by blue rectangles) connected and even form parts of the environment (golden block at the bottom) allow for a preventive type of assistance to prepare a driver to manage a situation or to aid the driver in a certain type of situation (see components represented by pink rectangles). The overall analysis or fusion of the situation is done components shown in green rectangles.

The functionalities provided by the architecture are of various forms of assistance:

- ***Preventive Assistance***: Here, there is no direct interaction with the situation. The goal is simply to prepare the driver by giving him the adapted information. The level of information in this sense should not be a cause for "overstress". The objective is to implement this condition by performing an overload/accuracy of information of GPS type. It is mainly a guide developed based on a priori knowledge of the situation (potential risks, ongoing development in the area and its specificity).
- ***Information Support*:** This second level corresponds to assistance in direct approach to the zone. It is meant to give routine type information to the driver. These are mainly reminders on the checks and controls to be performed with reference to the driver's environment.

- ***Assistance:*** This level can be considered as a driver aid. It is the activated automatic processes to verify controls and proceed with corrective measures, if needed (e.g. corrective measures or guide when driver is over-speeding, etc.).

4. The Driving Model

The driving model is the modelling of road environment and rules of conduct for different situations based on various different contexts. We have used an ontological approach for modelling the automobile domain knowledge in order to put in place a common conceptual language between the driver and the assistance system.

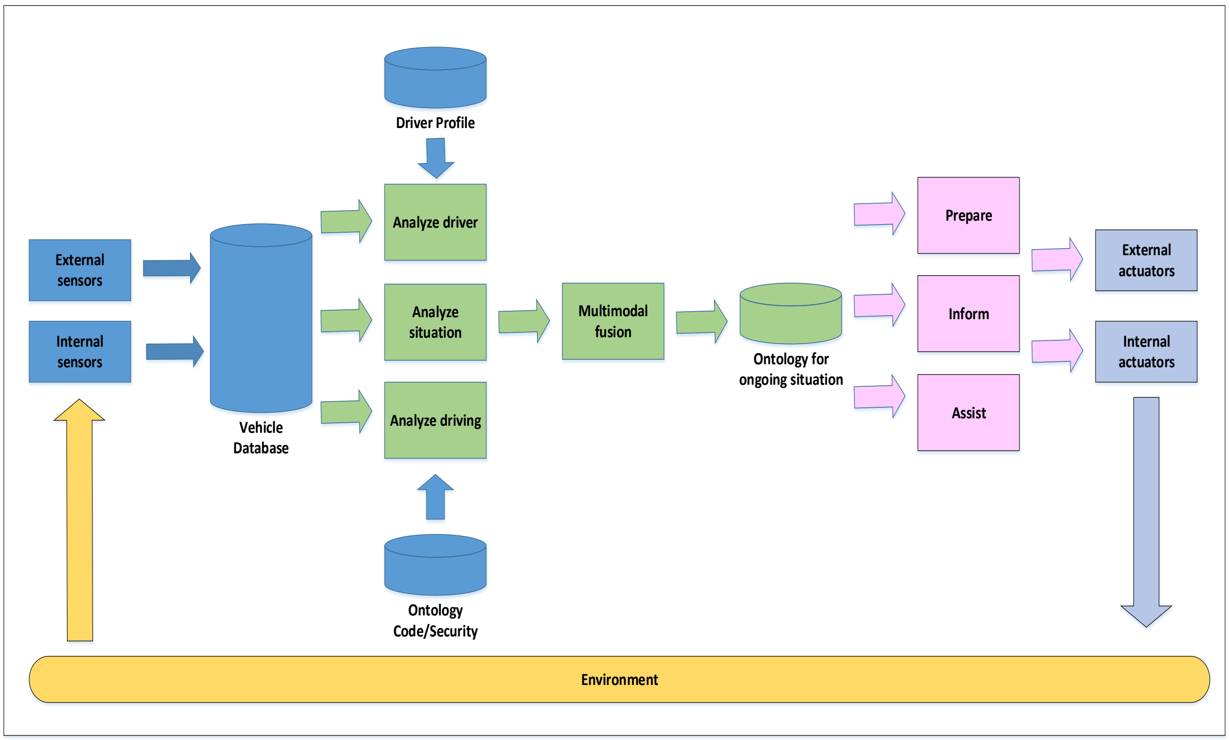

Figure 2: Architecture design with customization

4.1 The Basics of Ontology

Ontology is the whole structure of concepts and the relations representing the meaning of a given domain. It is studied in the field of artificial intelligence, and allows the representation of knowledge, and it is also used in the semantic web. In effect, there are several definitions or meanings attributed to this concept. The definitions the most common are those of [8], [9], and [10]. The first definition of the ontology in the field of informatics is proposed by [8] as they define ontology as: "the terms and the basic relationship with the vocabulary of a domain as well as the rules for combining terms and relations in order to define extensions of such vocabulary". In 1993, Gruber proposed the definition most cited, it defines ontology as: "an explicit specification of a conceptualization" [9]. [10] refines the definition of Gruber in considering ontologies as partial and formal specifications of a conceptualization. Ontologies are formal because they are expressed as formalism with formal semantics. They are partial because a conceptualization cannot always be fully formalized in such a framework, given the fact of ambiguities or of the fact that no representation of their semantics exist in the language of chosen representation.

The use of ontologies in the modelling of accident black spots situations in transport [11] and on assistance on search of data [12] shall take a significant boom because the contribution of semantic web to the realization of systems allows for the development of architectures with distributed components in the network and the quality of the expert knowledge and reasoning to be integrated into the systems. [13] uses ontology in modelling an Intelligent Driver Assistance System (I-DAS) for Vehicle Safety.

The need to develop ontology is very varied and depends on the application domain; we cite a number of them, including:

- ***The domain knowledge***: Ontologies allow the modelling of knowledge in a particular area, in which operates the system to develop.
- ***The communication***: ontologies provide a reliable and heterogeneous communication between people and machines (software agents or organizations) the fact that it allows one to put in place a language or a common conceptual vocabulary.
- ***Interoperability***: the explicit representation of knowledge in a given domain in the form of ontology allows one for greater reuse, a broader sharing and a more extended interoperability.
- ***The aid for specification of systems*:** The conceptual representation of the elements of a domain allows systems to achieve logical reasoning, called inferences, and to come up with conclusions capable of helping users or managers in his decisions.
- ***The indexing and searching of information***: In the semantic web, ontologies are used to describe the resources used. This allows greater precision in search results or in assignment of resources.

There are four types of components to formalize knowledge embedded in ontology, namely: the classes, the relations, the axioms and the instances.

- The *classes of concepts* are a set of words representing an abstract idea or a class of tangible objects.
- The *relation* represents a type of interaction between the concepts of a domain.
- The *axioms* are for structuring of sentences which are always true.
- The *instances* are used to represent the elements.

4.2 Representation of Road Environment

We have built a knowledge base to represent the environment of the road domain. This database is ontology to describe an automobile. The hierarchy of concepts is a tree of subsumption calculated according to the degree of restriction specified by the axioms of the concept. A concept C1 is subsumed by concept C2 if and only if all the instances of C1 are also instances of C2. A universal concept "Thing", which generalized all root concepts of different hierarchies of concepts, can be used to form a single global hierarchy, in order to avoid isolated concepts.

Figure 3 represents the four main concepts describing the set of data related to the automobile domain.

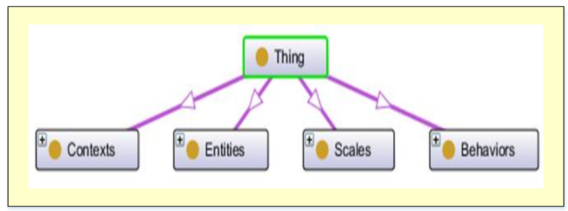

Figure 3: Ontology for vehicle

Figure 4 represents the class of the concept 'Roads' and its sub-classes of concepts that represent the different types of road. Under each type, we found roads as instances; each instance has properties that distinguish it from other forums such as the name of the route, the number of lanes on the road etc. The vehicle has a relationship with the road to indicate its location. As shown, we have the relation 'isLocated' which connects 'Car_1' and 'CityRoad_1', which is to say that the automobile is located at city road 1.

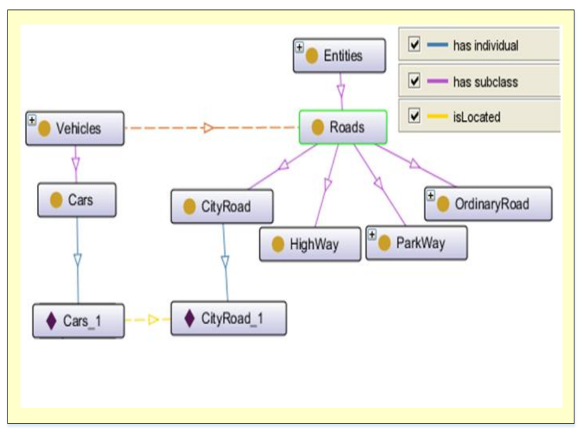

Figure 4: The concept "Roads"

Vehicle is a main entity that is found in the field "road". Figure 5 shows the sub-concept "Vehicles". Its sub-classes (automobiles, motorcycles, cars, etc.) represent the various types of this entity, and the relations that connect them with other concepts. The vehicles are represented with instances in the figure. 'Car' is an instance having its own entities.

The class of the concept 'Obstacles' is shown in Figure 6. It is the parent class of the two sub-classes 'hasObsSameLane' (i.e. obstacle in the same lane) and 'hasObsDifferentLane' (i.e. obstacle in different lane) which represent respectively all the obstacles that are found in the same traffic lane and in the opposite direction. An obstacle may be a vehicle, a stop, a tree, etc.

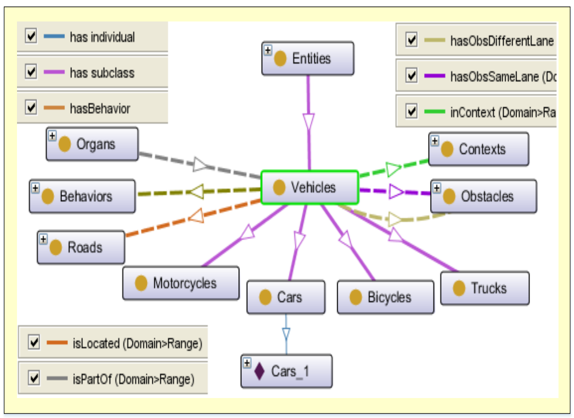

Figure 5: The concept "Vehicles"

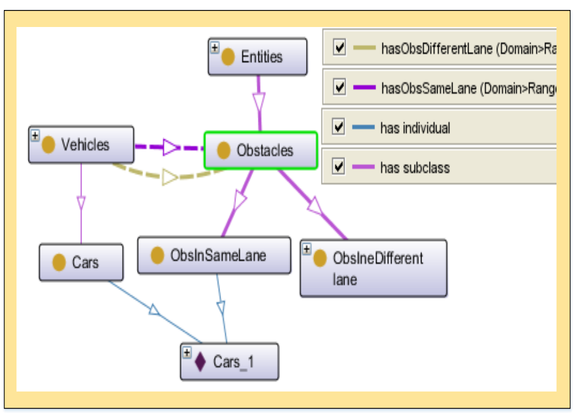

Figure 6: The concept "Obstacles"

Figure 7 shows the class "Behaviors" which describes the actions that can be done with vehicles. These behaviors are classified into 4 types (monitor, maneuver, manage and go). The relationship 'hasBehavior' represented by the orange arrow connects the concept 'vehicles' with the concept 'behaviors' to indicate what action to take in each driving situation, for example, 'Driver' 'hasBehavior' 'Overtake'.

Figure 8 shows the class of the concept 'Contexts' which describes the different contexts that we can find in a vehicle (safety, danger, etc.). For example, under the class 'dangers', there are various types of danger (telephone, fatigue, alcohol, and speed).

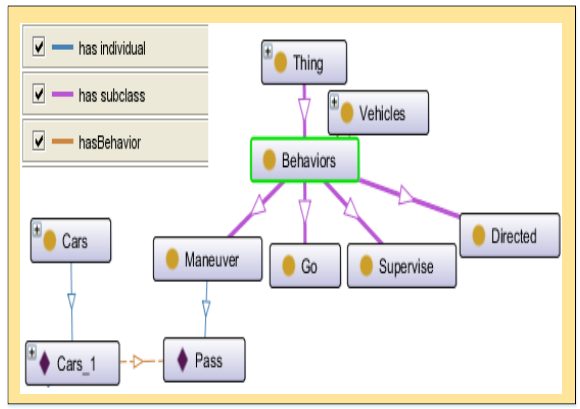

Figure 7: Sub-classes of the concept "Behaviors"

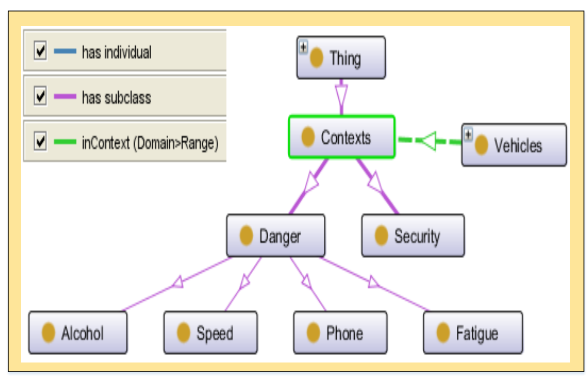

Figure 8: Sub-classes of the concept "Contexts"

4.3 Representation of Driving Rules

We have represented the rules of driving in the form of a set of rules SWRL 2 (Semantic Web Rule Language). See Figure 9. Each rule has two parts: the pre-condition and the post-condition. The pre-condition describes the state of the vehicle relative to driving context. The post-condition, on the other hand, is a command or an information message. Consider for example, Rule 6 in the figure states that: There is a concept called 'Obstacle'. 'Stop' is an obstacle. Such obstacle is located on the road. There is a concept called 'Vehicle'. An automobile is a vehicle. Such vehicle is located on the road. The road is of type urban road. The vehicle and the obstacle are both located on the same lane. The vehicle is found to have an average speed. The vehicle's distance from the obstacle is medium. Therefore the 'Behavior' suggested on the vehicle is to Slow Down.

```
rule1:  (?I_Vehicle1 rdf:type ns:Cars) (?I_Vehicle1 ns:isLocated ?I_Road) (?I_Road rdf:type ns:CityRoad)
(?I_Vehicle1 ns:haslane 1) (?I_obstacle1 rdf:type ns:ObsInSamelane) (?I_obstacle1 ns:isLocated ?I_Road)
(?I_obstacle1 ns:haslane 1) (?I_Vehicle1 ns:hasSpeed "Average") (?I_obstacle1 ns:hasSpeed "Slow")
(?I_Vehicle1 ns:hasDistanceObs1 "Average") -> (?I_Vehicle1 ns:hasBehavior "ChangeLane").

rule2:  (?I_Vehicle1 rdf:type ns:Cars) (?I_Vehicle1 ns:isLocated ?I_Road) (?I_Road rdf:type ns:CityRoad)
(?I_Vehicle1 ns:haslane 1) (?I_obstacle1 rdf:type ns:ObsInSameLane) (?I_obstacle1 ns:isLocated ?I_Road)
(?I_obstacle1 ns:haslane 1) (?I_Vehicle1 ns:hasSpeed "Rapide") (?I_obstacle1 ns:hasSpeed "Slow")
(?I_Vehicle1 ns:hasDistanceObs1 "Near") -> (?I_Vehicle1 ns:hasBehavior "ChangeLane").

rule3:  (?I_Vehicle1 rdf:type ns:Cars) (?I_Vehicule1 ns:isLocated ?I_Road) (?I_Road rdf:type ns:CityRoad)
(?I_Vehicle1 ns:haslane 1) (?I_obstacle1 rdf:type ns:ObsInSameLane) (?I_obstacle1 ns:isLocated ?I_Road)
(?I_obstacle1 ns:haslane 1) (I_Vehicle1 ns:hasSpeed "Slow") (?I_obstacle1 ns:hasSpeed "Average")
(?I_Vehicle1 ns:hasDistanceObs1 "Far") -> (?I_Vehicle1 ns:hasBehavior "RemainSameLane").

rule4:  (?I_Vehicle1 rdf:type ns:Cars) (?I_Vehicle1 ns:isLocated ?I_Road) (?I_Road rdf:type ns:CityRoad)
(?I_Vehicle1 ns:haslane 1) (?I_obstacle1 rdf:type ns:ObsInSameLane) (?I_obstacle1 ns:isLocated ?I_Road)
(?I_obstacle1 ns:haslane 1) (?I_Vehicle1 ns:hasSpeed "Slow") (?I_obstacle1 ns:hasSpeed "Slow")
(?I_Vehicle1 ns:hasDistanceObs1 "Near") -> (?I_Vehicle1 ns:ahasBehavior "Changelane").

rule5:  (?I_Vehicle1 rdf:type ns:Cars) (?I_Vehicle1 ns:isLocated?I_Road) (?I_Road rdf:type ns:CityRoad)
(?I_Vehicle1 ns:haslane 1) (?I_obstacle1 rdf:type ns:ObsInSameLane) (?I_obstacle1 rdf:type ns:Stop)
(?I_obstacle1 ns:isLocated ?I_Road) (?I_obstacle1 ns:haslane 1) (?I_Vehicle1 ns:hasDistanceObs1 "Near")
-> (?I_Vehicle1 ns:hasBehavior "Brak").

rule6:  (?I_Vehicle1 rdf:type ns:Cars) (?I_Vehicle1 ns:isLocated?I_Road) (?I_Road rdf:type ns:CityRoad)
(?I_Vehicle1 ns:haslane 1) (?I_obstacle1 rdf:type ns:ObsInSameLane) (?I_obstacle1 rdf:type ns:Stop)
(?I_obstacle1 ns:isLocated ?I_Road) (?I_obstacle1 ns:haslane 1) (?I_Vehicle1 ns:hasDistanceObs1 "Near")
(?I_Vehicle1 ns:hasBehavior "Accelerate")
-> (?I_Vehicle1 ns:hasDanger "SpeedDanger").
```

Figure 9: Representation of rules of driving

In Figure 10, we show a sample situation of obstacle avoidance in the case where there is just one obstacle:

```
rule1:  (?I_Vehicle1 rdf:type ns:Cars) (?I_Vehicle1 ns:isLocated ?I_Road)
        (?I_Road rdf:type ns:CityRoad) (?I_Vehicle1 ns:haslane 1)
        (?I_obstacle1 rdf:type ns:ObsInSamelane) (?I_obstacle1 ns:isLocated ?I_Road)
        (?I_obstacle1 ns:haslane 1) (?I_Vehicle1 ns:hasSpeed "Average")
        (?I_obstacle1 ns:hasSpeed "Slow") (?I_Vehicle1 ns:hasDistanceObs1 "Average")
        -> (?I_Vehicle1 ns:hasBehavior "ChangeLane").
```

Figure 10: Rule of driving in the obstacle avoidance situation

Consider the rule of driving in obstacle avoidance situation, shown in Figure 10, as applied to a driving situation shown in Figure 11.

- A vehicle (I_Vehicule1) is being driven on a road.
- The vehicle (I_Vehicule1) is of type automobile (the orange car).
- The road (I_Route) is an urban road
- The vehicle (I_Vehicule1) is rolling in lane 1
- An obstacle (I_obstacle1) exists in the same road and in the same direction, (the green car)
- The vehicle (I_Vehicule1) is traveling with an average speed relative to the speed of the obstacle (I_obstacle1) which is 'slow'
- The distance between the obstacle and the vehicle is Average _ the vehicle must have behaviour as 'Change lane'.

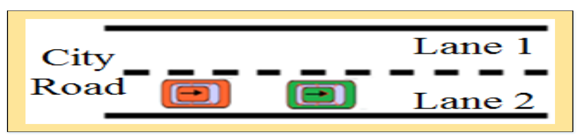

Figure 11 : Sample simulation for obstacle avoidance situation

4.4 Turn Left in an Intersection

The following table describes the rules of Turn Left at each step T as shown in the Table 2.

The explanation for each step in Table 2 is explained below:

- In step T0, we verify the location of the vehicle in the road and its distance from the stop signal. If this distance is far, we display a message to the driver to prepare for Turn Left situation.

- In step T1, we check if the stop signal is in the same direction as the vehicle. We then verify the distance between the two. If the distance is average, we inform the driver to prepare to stop.
- When the distance between the car and the stop signal is 'near' (between T1 and T2) then it sends a message to the driver to slow down. If the driver does not react accordingly, for example instead of braking it accelerated, in this case the system displays an alert message.
- In step T2, if the vehicle stops at the stop signal, then the system displays a message to the driver to look to the right and then to the left.
- X In T3, we verify the distance between the vehicle driver and the vehicles that circulate in the second route. If the distance is far then we send driver the message to "turn left ".

Table 2: Detailed Implementation of Turn Left Driving Situation

Step	States	Rules	Command	Message
T0	• Vehicle (I_Vehicule1) located at urban road (I_Route) • Stop sign located at urban roadway (I_Route) • Stop sign (I_Obstacle1) located after pizzeria • The stop is far away from the vehicle • There is intersection of type T	R1- Context: natural guidance	-	After the pizzeria, there is a stop then you must turn left. Please look well at the right, then look at the left before proceeding
T1	• Vehicle in lane 1 • Stop in lane 1 • The distance between vehicle and stop is "average"	R1-Context: braking	-	You are near the stop signal.
T1-T2	• The distance between vehicle • and the stop is "near" • The distance between vehicle • and the stop is "near" • The vehicle accelerates	R5- Context: braking	Brake	-
T2	• The vehicle stopped at the stop	R3- Context: Turn Left	-	Look to the right, then look to the left
T3	• Obstacle 2 in route 2 lane 1 • Obstacle 3 in route 2 lane 2 • Distance (vehicle, obstacle2) = far • Distance (vehicle, obstacle3) = far	R4- Context: Turn Left	Turn left	-

5. Application in Vehicle Overtaking and Turning to the Left

In a system that executes safe overtaking in an expressway, the context of the traffic environment would be accurately represented through the value obtained from various sensors. As shown in Figure 12, the following sensory equipment are needed: (i) multimode radar – detects vehicles at the back of the car; (ii) short-range radar – detects the vehicles that are tailing the vehicle in consideration; (iii) stereo multi-purpose camera and ultrasonic sensors – to detect obstacles at the sides of the vehicle in consideration and (iv) mid-range radar and infrared camera – to detect obstacles in front of the vehicle in consideration.

5.1 Application for the Turn Left Situation

Two particularly interesting driving situations have captured our attention. This is the "turn left" and the overtaking on the multi-lane highway. Concerning the Turn Left situation (see Figure 13), the following modes of interaction are accounted for: (i) Detection of danger, (ii) Detection of STOP signal, (iii) Emergency braking, (iv) To help estimate the speeds of other vehicles, and (v) Detection of obstacles on the ground. Overtaking (see Figure 14) is particularly dangerous and requires strong attention and coordination of the driver on level perception (temporal and spatial), cognitive (analysis of the situation) and the actions to perform. The driver must monitor the two adjacent lanes, visualize other drivers and act safely.

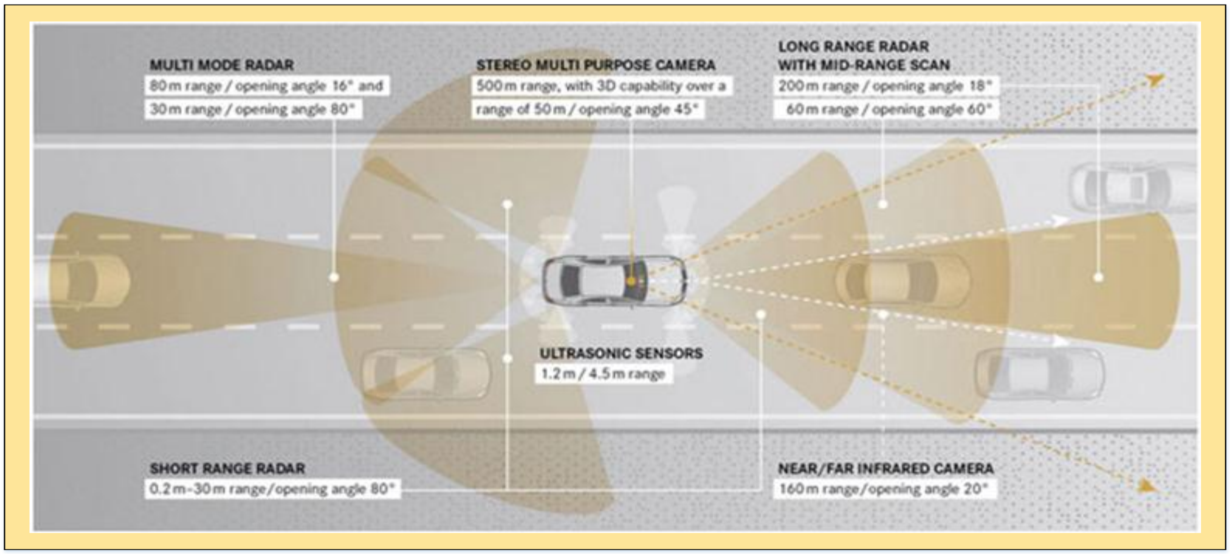

Figure 12: Configuring sensors for detection during an overtake

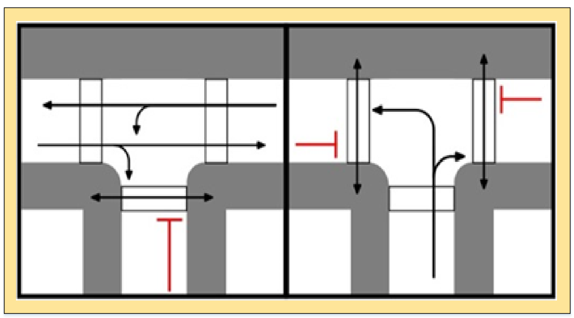

Figure 13: The T intersection to two phases

Figure 14: Overtaking in a highway

The Turn Left situation is shown on Figure 12 as defined by the Centre for Studies on networks, transport, urban planning and public constructions (CERTU). Maintaining functionality in two phases assumes that the vehicles turning to the left can be stuck in the intersection without interference from the flow of traffic turning to the right and the traffic turning to the left without blocking each other. When there is less number of vehicles turning left at each cycle then there will be possibility that a vehicle would be stuck in an intersection.

The number of vehicles that are turning left at each cycle depends on the number of cycles per hour and the duration of the cycle. If G denotes the number of vehicles turning left by hour, g is the number of vehicles turning to the left by cycle: g = G * Cy/3600. Table 3 gives the values of g rounded to the upper unit.

Table 3: Relationship of number of vehicles turning left per hour and turning to the left by cycle

C_y	G						
	50	100	150	200	300	400	500
50	1	2	3	3	5	6	7
60	1	2	3	4	5	7	9
75	2	3	4	5	7	9	11
90	2	3	4	5	8	10	13

5.2 Short Cycle=reducing the problems related to left-turn:

A simple glance at Table 3 shows the need to operate on short cycles to ensure that a low number of vehicles get stuck in the intersection and thus reduce the discomfort for all those turning right and the adverse blockage of traffic for those turning to the left.

In the situation shown in Figure 15, the driver must pay particular attention to two traffic directions. In addition, the situation may be reduced into 5 or 6 steps:

- **Step 1**: The driver drives without constraint towards the direction of T intersection.

- **Step 2**: The driver is approaching the intersection and will notice the STOP sign. At this stage, the driver must begin to slow down the vehicle. It may also be possible that other vehicles (considered as obstacles) are already slowing down or totally stopped in front of him.
- **Step 3**: The driver is stopped and well positioned at the level of the stop signal; the driver must assess the situation and decide whether to insert into the intersection traffic or not.
- **Step 4**: The driver inserts himself into the intersection traffic and crosses the lane 2 that is opposite to his direction.
- **Step 5**: The driver will be positioned parallel to and well centre in lane 1
- **Step 6**: The danger has been passed; the driver may now adapt his speed to the traffic density of his lane

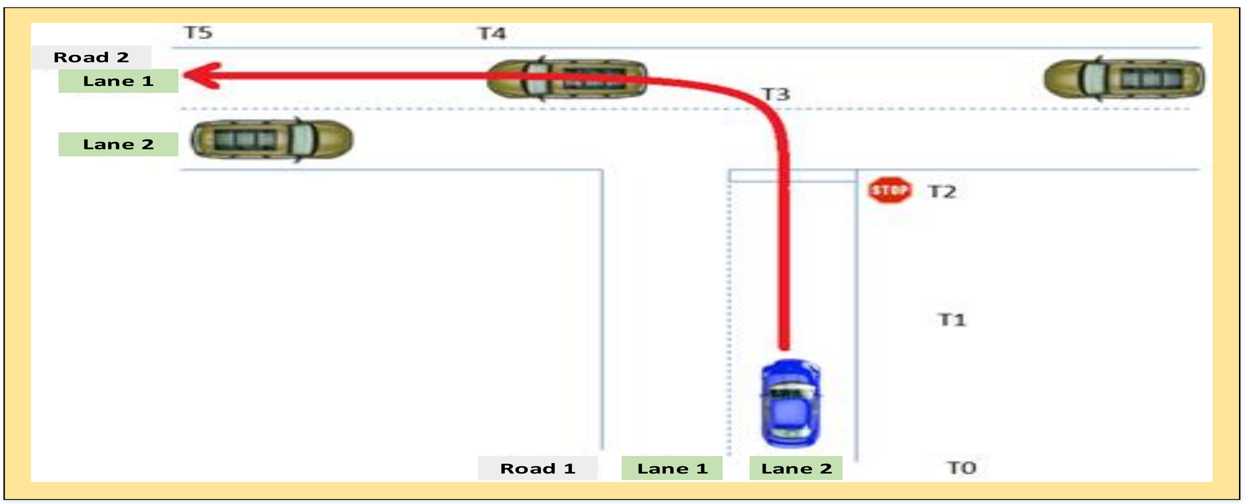

Figure 15: Shortening the Cycle for Turn Left Traffic

5.3 Turn Left as a Situation of Constraint

The "Turn left" is a constraint situation. This is due to the following reasons:

- The decomposition of the scenario is more complex from a human point of view (many faculties sought, including the working memory) and also technical aspect requiring rigorous analysis of the driving situation as well as the human factors of the driver.
- It involves many environmental parameters such as driving in the city, the obstacles (other vehicles, signals, pedestrians, etc.).
- It is identified as a situation posing a lot of difficulties for elderly people.
- It requires internal sensors for the vehicle
- It may also require external sensors for the vehicle

The chosen scenario and the acquisition of data has thus been carried out on the different steps, following real life driving situation (see Figure 16) in a vehicle equipped with camera that is made possible by our university partner, CEREMH. The diagram demonstrates each action before the stop signal, in

[2]http://www.certu.fr

front of the stop signal and after passing through the stop signal.

Figure 16: Implemented Turn Left scenarios

5.4 Applying the Rules on Turn Left Situation

We will show examples of these rules and the result of the execution of each. Figure 17 shows the rule executed between steps T1 and T2. Here, a car is in the same road location as the obstacle (i.e. Stop sign). The distance between the two is “near”. The system therefore invokes the behavior for the driver to ‘Brake’.

```
rule5: (?I_Vehicle1 rdf:type ns:Cars) (?I_Vehicle1 ns:isLocated ?I_Road)
       (?I_Road rdf:type ns:CityRoad) (?I_Vehicle1 ns:haslane 1)
       (?I_obstacle1 rdf:type ns:ObsInSameLane) (?I_obstacle1 rdf:type ns:Stop)
       (?I_obstacle1 ns:isLocated ?I_Road) (?I_obstacle1 ns:haslane 1)
       (?I_Vehicle1 ns:hasDistanceObs "Near")
        -> (?I_Vehicle1 ns:hasBehavior "Brak")
```

Figure 17: Driving rule on the context 'braking'

The result of the execution of this rule is shown in Figure 18. This is the implemented program associated with the ontological model. In this specific case, the system suggests that the driver should step on brake/slow down.

```
Console
<terminated> Main (1) [Java Application] C:\Program Files\Java\jre1.8.0_40\bin\javaw.exe (25 juin 2015 16:22:56)
1 obstacle détecté
TAG
-------------------------------------------------------
| vehicle  | obstacle1 | distanceObstacle1 | behavior |
=======================================================
| ns:Car_1 | ns:Stop_1 | "Near"^^w3:string | ns:Brak  |
-------------------------------------------------------
```

Figure 18: Execution Result of rules "Context: Braking"

And the rule that is enabled in the event that the driver does not govern himself well is presented in Figure 19. Here, the distance between the vehicle and the obstacle (i.e. Stop sign) is “near” and yet the driver behavior is “accelerating”. The system invokes braking.

```
rule5: (?I_Vehicle1 rdf:type ns:Cars) (?I_Vehicle1 ns:isLocated ?I_Road)
       (?I_Road rdf:type ns:CityRoad) (?I_Vehicle1 ns:haslane 1)
       (?I_obstacle1 rdf:type ns:ObsInSameLane) (?I_obstacle1 rdf:type ns:Stop)
       (?I_obstacle1 ns:isLocated ?I_Road) (?I_obstacle1 ns:haslane 1)
       (?I_Vehicle1 ns:hasDistanceObs "Near")
        -> (?I_Vehicle1 ns:hasBehavior "Brak")
```

Figure 19: Rule of driving in the context “Braking with Assistance”

Figure 20 describes the result of the execution of the rule cited in Figure 19. Here, the result says that danger due to speeding is imminent. An intervention is invoked.

```
Console
<terminated> Main (1) [Java Application] C:\Program Files\Java\jre1.8.0_40\bin\javaw.exe (25 juin 2015 16:29:04)
1 obstacle détecté
TAG
------------------------------------------------------------------------
| vehicle  | obstacle1 | distanceObstacle1 | behavior      | danger         |
========================================================================
| ns:Car_1 | ns:Stop_1 | "Near"^^w3:string | ns:Accelerate | ns:SpeedDanger |
------------------------------------------------------------------------
```

Figure 19: Execution Result of rules “Context: Braking with Assistance"

5.5 Contribution of the System

Our system considers the context of the vehicle, its position, its speed and the presence of obstacles (i.e. a vehicle, STOP sign, etc.) and the vehicle’s distance from the obstacle. Through the rule of the driving invoke using ontology, our system is able to detect the situation and propose a visual/oral guide to the driver. It can also detect an incorrect situation and intervene actively to avoid the occurrence of a fatal accident. Our system uses the Turn Left situation as a base case. Other traffic cases will be considered afterwards.

6. Conclusion and Future Works

In this paper, we have demonstrated how we have modeled the road environment with an ontological approach. We also have modeled the rules of driving in order to realize a driving assistance system. The objective of our work in this phase (phase 1) concerns about aiding the drivers to prepare and/or manage risky driving situations. There are many situations that may be described as risky situations. They all depend on the driver, the non-adaption of proper driving behavior in a zone or in an intersection, of bad expertise for a young driver, of limited traction or of bad use of driving assistance system.

Our proposition is to assist drivers by acting on accident prevention in the form of personalized advice when going into a certain area and on a driving approach before performing automatic driving task. The level of assistance is of three types: preventive assistance, information support and full assistance.

We have developed an architecture that is capable of capturing the driving context. Internal and external sensors will provide actual data that will be fed to the system. Based on the collected information and ontological information, such as rule of driving, we will be able to analyze the driving situation. Multimodal fusion and ontology are used to prepare, inform, and assist the driver to deal with the current driving situation. These suggested behaviors are meant that driver acts on them accordingly. In case of driver not acting properly, actuators may be activated to prevent an imminent vehicular accident from happening.

This paper presents the Turn Left situation as the first phase of our work. We study this particular situation in order to specify and test our assistance system. Here, a driver makes two tasks. He monitors other vehicles in the different lanes and directions while he assures proper driving behavior himself. Turning to the left is often a dangerous situation. Our analysis of Turn Left situation has enabled us to define a dedicated ontology. Our modeling is accompanied by a bibliographic study of actual driving participant and the risks associated in the driving situation. Our proposed architecture integrates two modalities of assistance (visual and oral) to the driver.

Future works include the analysis of the context of the driver himself. This includes the profile of the driver (i.e. elderly, handicapped, young driver, driver who is not familiar with the road) and whether the driver is tired, fatigue, etc. Also in consideration is the mode by which the oral message will be delivered to the driver (i.e. male/female voice, volume adaptation based on the severity of the situation, etc.).

References

[1] Ministry of Transportation, Government of Ontario, Canada. (2014, 9 July 2015). Changing Directions - Left Turns. Available: http://www.mto.gov.on.ca/english/dandv/driver/handbook/section2.6.4.shtml.

[2] Daimler-Benz. (2003). Bas Plus with Cross-Traffic Assist. Available: http://techcenter.mercedesbenz.com/en_CA/bas_plus_cross_traffic_assist/detail.html.

[3] BMW. (2013). Journées Technologiques Bmw - La Voiture Automatisé, C'est Pour Demain,. Available: http://automobile.challenges.fr/dossiers/20101214.LQA3485/journees-technologiques-bmw-la-voiture-automatisee-c-est-pour-demain.html.

[4] GM. (2013). Available: http://www.caradisiac.com/Siri-le-systeme-d-assistance-vocal-d-Apple-bientot-chez-General-Motors-82927.htm.

[5] Audi. (2013 - 1). Available: http://articles.sae.org/11664/.

[6] Audi. (2013 - 2). Available: http://www.audiusanews.com/newsrelease.do;jsessionid=CFA91BA1FDB98213DBC0DD033103A938?&id=2172&allImage=1&teaser=audiresearchers-four-u.s-universities-begin-work-solutions&mid=1.

[7] S. Al-Sultan, A. Al-Bayatti and H. Zedan, "Context-Aware Driver Behavior Detection System in Intelligent Transportation Systems," IEEE Transactions on Vehicular Technology, vol. 62, pp. 4264 - 4275, 2013.

[8] Neches, R., Fikes, R., Finin, T., Gruber, T., Patil, R.., Senator, T., et al. (1991) Enabling Technology for Knowledge Sharing. AI Magazine. pp. 36-56.

[9] Gruber, T. R., "A Translation Approach to Portable Ontology Specifications," Knowledge Acquisition, vol. 5, pp. 199 - 220, 1993.
[10] Guarino, N., "Formal Ontology, Conceptual Analysis and Knowledge Representation," Human-Computer Studies, vol. 43, pp. 625-640, 1995.
[11] Maalel, Ahmed, Mabrouk, Habib Hadj, Mejri, Lassad, and Ghezela, Henda Hajjami Ben, "Development of an Ontology to Assist the Modeling of Accident Scenario Application on Railroad Transport," Journal of Computing, vol. 3, 2011.
[12] Charest, Michel and Delisle, Sylvain, "Ontology-Guided Intelligent Data Mining Assistance: Combining Declarative and Procedural Knowledge," presented at the IASTED International Conference, 2006.
[13] S. Kannan, A. Thangavelu, and R. Kalivaradhan, "An Intelligent Driver Assistance System (I-Das) for Vehicle Safety Modeling Using Ontology Approach," International Journal of Ubiquitous Computing, vol. 1, pp. 15 – 29, 2010.

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