Ontology-Based Context Awareness for Driving Assistance Systems

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***Abstract*— Within a vehicle driving space, different entities such as vehicles and vulnerable road users are in constant interaction. That governs their behaviour. Whilst smart sensors provide information about the state of the perceived objects, considering the spatio-temporal relationships between them with respect to the subject vehicle remains a challenge. This paper proposes to fill this gap by using contextual information to infer how perceived entities are expected to behave, and thus what are the consequences of these behaviours on the subject vehicle. For this purpose, an ontology is formulated about the vehicle, perceived entities and context (map information) to provide a conceptual description of all road entities with their interaction. It allows for inferences of knowledge about the situation of the subject vehicle with respect to the environment in which it is navigating. The framework is applied to the navigation of a vehicle as it approaches road intersections, to demonstrate its applicability. Results from the real-time implementation on a vehicle operating under controlled conditions are included. They show that the proposed ontology allows for a coherent understanding of the interactions between the perceived entities and contextual data. Further, it can be used to improve the situation awareness of an ADAS (Advanced Driving Assistance System), by determining which entities are the most relevant for the subject vehicle navigation.**

I. Introduction

Modern vehicles increasingly include sensor-based systems to provide safety functions. Whilst strong advances have been made on perception, estimating the spatio-temporal state of the perceived entities is not sufficient to infer whether or not the subject vehicle can navigate in safe conditions [1].

The use of contextual information, in the form of features stored in digital maps helps to increase the situation awareness. This contextual data enables to give sense to the acquired sensor information, to understand how entities are expected to behave in the driving space. For example, in the situation 2 of Fig. 1, a pedestrian that is perceived next to a pedestrian crossing is more likely expected to cross the road than if there is no nearby pedestrian crossing (situation 1 of Fig. 1). Without knowing how pedestrians standing next to a crossing usually behave, it is difficult to interpret sensors data about the pedestrian state. In the situation 3 of Fig. 1, another vehicle is implied. By knowing that the lead vehicle (in red) is about to reach the pedestrian close to the crossing, it allows to infer that it may have to stop to let the pedestrian cross the road, and therefore that the subject vehicle has to stop as well. In this example, the interaction between the lead vehicle, the pedestrian and the pedestrian crossing has direct influence on the subject vehicle.

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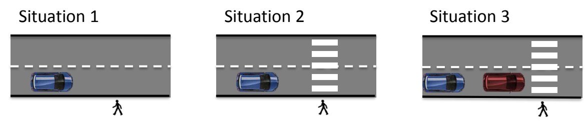


Fig. 1: Interaction between road entities define the context. Example of 3 situations.

Associating perceived information with contextual information to infer the relevance of a situation can be a complex problem due to the multiple scenarios that can occur. In this paper, the use of ontologies is introduced as a solution to this problem. The tenet is to provide a conceptual description of the entities and contextual objects which can be met by a vehicle in a driving space. This structure allows for the interpretation of road situations, which then enables to estimate the relevance of the perceived entities with respect to the subject vehicle.

The reminder of the paper is organized as follows. A state of the art review on issues related to situation understanding for driving assistance systems is presented in Section II. A brief description of the general concept of ontologies is given in Section III. The ontology defining the relationships between the perceived information and contextual data is described in Section IV. The application of the ontology in real-time under controlled conditions (at road intersections) to demonstrate the approach is presented in Section V. Conclusions complete the paper.

II. Related Work and Problem Statement

A major challenge resides on understanding the vehicle situation within its context. For example, understand the driver intention or awareness is very much dependent on its context, that is the spatio-temporal relationships between the vehicle and its environment. It is necessary to infer the relevant information [2]. In this section, the different approaches to gain situation understanding in ADAS (Advanced Driving Assistance System) are presented. The findings are partitioned into two parts according to the perspective taken, the vehicle itself or the overall context.

A. Vehicle centric situation understanding frameworks

Driver maneuver intention is inferred by several ADAS systems. For example, a vehicle motion model is used to estimate the driver maneuver intention for lane change in

[3]. By predicting the vehicle trajectories, the likelihood of potential collision with other road entities can be inferred [4]. For specific traffic situations, context elements and traffic rules have to be taken into consideration to enhance the estimation of the driver intention. For instance, the driver intention to violate a stop at an intersection can be estimated [5]. Risk assessment can be computed by comparing what the driver intends to do with what (s)he is expected to do, with respect to its context (traffic rules and other entities sharing the same driving space) [6]. Existing vehicle situation understanding frameworks are limited in the number of contextual entities, due to the difficulties on establishing the spatio-temporal relationships between all the perceived entities and the subject vehicle.

B. Global situation understanding frameworks

As previously discussed, to better understand the situation of the subject vehicle, it is important to also understand the situation of all entities sharing the same navigable space. A perceived situation can be decomposed into "parts of situations" recognizable through a Bayesian approach. It is applied to the configuration of other vehicles concerned in the situation [7]. While this probabilistic approach takes into account uncertainties, it does not take into account chain reactions. This problem is difficult to solve with the probabilistic approach alone, since all contextual entities need to be represented within a unique and adaptive context model.

As a solution to the problem of interaction between road entities, a knowledge based framework using first order logic is presented in [8]. The main limitation of this framework is that all road entities are conceptually the same kind of object. Semantic information about road entities (types, etc.) can be defined within an ontology used in a case-based framework [9]. The tenet is to recover similar or resembling situations that the subject vehicle already met, to infer the most corresponding behaviour that it should have. While several types of entities are considered, interaction between these are ignored.

The literature proposes several approaches which present scene understanding frameworks based on description logic. Geometric road infrastructures at road intersections have been described within an ontology in [10]. This inspired the authors of [11] who propose an ontology based traffic model to infer conflict between vehicles reaching the same intersection. To our knowledge, one of the most recent work in scene understanding based on ontologies is [12]. It proposes a generic description of road intersections which is adaptable to every intersection. It has been demonstrated using simulation techniques [13].

C. Problem statement

The literature has shown that situation understanding for ADAS application remains a challenge. It has been understood that the interaction between types of entities are relevant to better understand the situation [1]. However, to our knowledge, there is no previous work that proposes to relate the interactions between all the entities perceived by the subject vehicle with respect to the context, to infer how other entities are likely to behave and to interact with the subject vehicle. Currently there is no ontology addressing fully this problem, however the literature has also shown that ontologies are suited to consider object properties and their relationships, to infer additional knowledge. Further, chain reactions can be understood in a direct manner.

This paper proposes an ontology-based framework that provides human like reasoning about the driving environment using information from its on-board sensors, maps and vehicle state. The ontology consists of a conceptual description of different entities found in road scenarios. That is by using an ontology formulation it is claimed that it is possible to infer a coherent understanding of the vehicle situation and thus the relevance of the perceived entities.

III. Ontologies

An ontology has been defined as "a formal, explicit specification of a shared conceptualization" [14]. It is a semantic tool, understandable by humans and computers, that consists of a formalized representation of knowledge about a field of discourse. That is a hierarchical description of the meaning of terms, and of the relationships that exist between those terms. The literature defines an ontology as a knowledge-base, composed by a terminological box (TBox) and by an assertional box (ABox). They are defined as follows:

- The TBox defines the concepts that the ontology describes. Every concept of the domain is called a Class that can be affected by data type properties, known as attributes. Relationships between classes are defined by taxonomic relations, axioms (classes linked by object properties) and rules (e.g. the Semantic Web Rule Language [15]). Some constraints on properties, can also be defined.
- The ABox declares the instances of concepts, known as Individuals. Real world data can be stored in an ontology through the ABox. Data and object properties can be attributed to individuals.

The representation of knowledge in an ontology is based on Description Logic (DL). The Ontology Web Language (OWL) is today the most popular file format to store ontologies, based on Resource Description Framework (RDF) format [16]. Several tools are available to edit ontologies and to verify their consistency, such as Protege, Swoops, etc [17].

To fully take advantage of ontologies, reasoning has to be carried out on it. Several reasoners exist to achieve this task. These include Pellet, Fact++, Hermit or also Racer [18]. They enable several inference services, like checking for ontology consistency, or inference of subsumption, of class equivalence, etc. [12].

IV. Proposed Ontology-Based Concept

The core ontology presented in this section aims to provide a framework to understand and interpret a context when perceived by vehicle sensors. The potential of the ontology resides on the different relationships that can be established between various road entities, and thus inferences of behaviour in medium to long term. Inferences can be used for ADAS functions.

It is important to note that processing time for reasoning depends on the size and complexity of the ontology. Therefore efforts were made to keep the ontology simple, whilst precise, coherent and accurate for context understanding. In addition, the objective was not to design an exhaustive ontology that considers every type of context entity, but rather to design a coherent and easily extendable ontology based framework.

A. The Ontology TBox

1) Classes: The taxonomy of the ontology is defined by three major classes, as shown by the blue part of Box 1 in Fig. 2. These classes represent the different types of entities found in typical road contexts:

- Mobile entities. These entities are only perceived in real time, that is their presence and position cannot be a-priori known. The most common mobile entities which can be found are split into 2 categories: vehicles (car, trucks and bikes) which move on the road, and pedestrians who usually move next to the road. It is assumed that vehicles respect traffic rules and pedestrians cross the road on pedestrian crossings.
- Static entities. These are part of the road network, and are always present. Basically, all static entities can be stored in digital maps and appear in the electronic horizon (road elements ahead of the subject vehicle). Currently, the ontology stores static entities related to road intersections, and to other infrastructures which have direct influence on the vehicle behaviour (bumpers, pedestrian crossing). Other types of static entities could be stored in the ontology.
- Context parameters (spatio-temporal). The relationship between 2 entities depends on their state, and on the distance that separates them. For example, the interaction between 2 vehicles on the same lane (same speed), separated by 90m is not the same if the vehicles are moving at 30km/h or at 90km/h. At 30km/h, the leading vehicle is 6s before the other vehicle, so there is no interaction between the vehicles. However, at 90km/h, 2s separates the vehicles, and the interaction between them will be established, thus the level of monitoring will be different. Through the context parameters, 3 thresholds are set in the ontology to define when it is estimated that a vehicle is following another one, when a vehicle is about to reach a static entity, and when a pedestrian is close to a static entity.

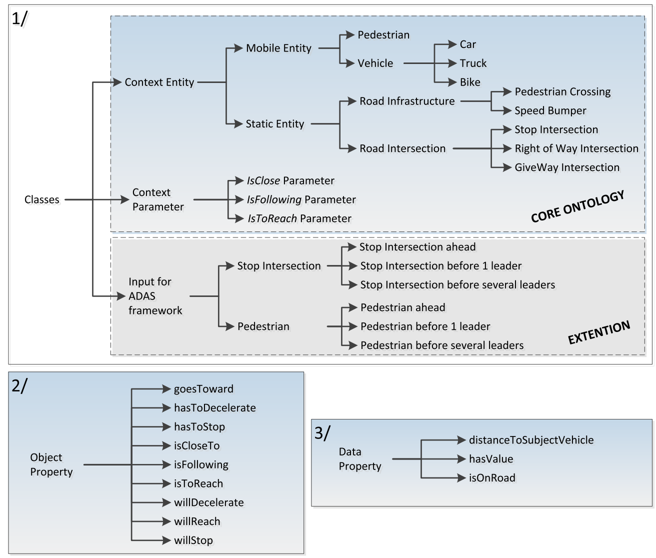


Fig. 2: Ontology classes, object and data properties. Blue boxes belong to the core ontology. Green box belongs to extension of the core ontology (presented in Section V).

2) Object Properties: The relationships and interactions between the concepts are also defined in the ontology. For this purpose, object type properties (roles) have to be defined first. These aim to define triples, in other words relationships between 2 concepts (i.e. class1 - object property - class2), as shown in Box 2 (Fig. 2). These properties describe the state of the mobile entities (*goes toward*, *is close to*, etc.), their near future behaviour (*is to reach*, *will decelerate*, *will reach*, etc.) and what behaviour they may have to keep their situation safe (*has to stop*, *has to decelerate*, etc.).

3) Data Properties: These properties (see Box 3 in Fig. 2) are used to assign properties to individuals (defined in the ontology ABox). Every individual for the mobile and static entities must be defined with its position in the scene. The origin of the reference frame used to describe positions is the subject vehicle, therefore every individual is declared with a value of *distanceToSubjectVehicle*. In addition, since pedestrians can either be on the road, or next to the road, this information has to be known by the ontology through the *isOnRoad* property. Finally, values are given to the Context Parameter classes through the *hasValue* data property.

B. The Ontology ABox

The ontology ABox contains instances of classes previously defined in the TBox. Four individuals are mandatory (even if no context entity is present in the context) to enable the ontology to work and reason correctly:

- One instance of *vehicle*, which is the origin of the frame used to position all the other entities. This vehicle is the subject vehicle in which the ADAS (that uses the ontology) runs. All the other instances of road entity will be positioned with respect to this individual. Thus, the *distanceToSubjectVehicle* data property is affected to the individual and is set at 0.

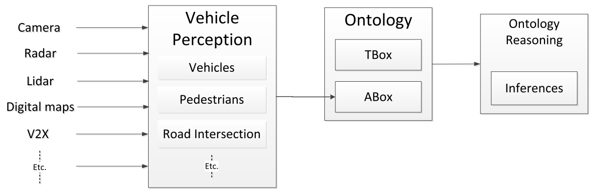


Fig. 3: Diagram of the framework (compatible with every type of sensor)

- One instance of *isCloseParameter* with the *hasValue* data property. The value of the property sets the maximum distance between a pedestrian and a static entity to consider them close enough to interact.
- One instance of *isFollowingParameter* with the *hasValue* data property. The value of the property sets the distance between 2 vehicles from which it is considered that one vehicle is no longer following the other one. This value should depend of the speed of the vehicles.
- One instance of *isToReachParameter* with the *hasValue* data property. The value of the property sets the distance of a vehicle to a static entity from which it is considered that the vehicle is about to reach (in a few seconds) the static entity. It depends on the vehicle speed.

Then, one other individual is created for each entity present in the environment (and sensed by the sensors). The ontology does not depend on the sensor technologies used to perceive the road environment, it only expects precise information about the type of the perceived entities and their position on the road (through the *distanceToSubjectVehicle* data property) with respect to the subject vehicle. That is, all perception technologies could be used to feed the ontology ABox, as illustrated by Fig. 3.

C. Rules

The rules are part of the TBox (see Section IV-A), however for the sake of clarity, it has been preferred to present them after the ABox. They are actually the core of the ontology, they provide intelligence for reasoning about contexts. In our case, they consist in defining axioms which are not general, but axioms which affect individuals (from the ABox) with respect to the road context. Basic description logic axioms are not expressive enough and only enables to define basic class equivalences. Therefore SWRL rules had to be used. SWRL rules allow to define much more complex and expressive rules, and perfectly meet our needs. However, reasoning on them can be computationally expensive, therefore an effort was made to keep a reasonable amount of rules in the ontology.

In the proposed ontology, 14 rules were created (only some of them will be briefly described in the following paragraphs) which enable to reason on the individuals and to affect object properties to them, such as their spatio-temporal relationship (is an entity following, going towards, close to, or about to reach another entity ?) and their future behaviour in the medium to long term (has the entity to stop, to decelerate ? or will it reach, stop or decelerate ?). Two example of rules are presented in the following paragraphs.

Concerning the spatio-temporal relationships between entities, the rules need to take the context parameter classes into consideration. For this example, the rule that defines when an entity is following another entity is written as follows (in SWRL language):

```
vehicle(?v1) ∧ distanceToSubjectVehicle(?v1,?d1)
∧ vehicle(?v2) ∧ distanceToSubjectVehicle(?v2,?d2)
∧ isFollowingParameter(?f) ∧ hasValue(?f,?fParam)
∧ subtract(?sub,?d2,?d1) ∧ lessThan(?diff,?fParam)
→ isFollowing(?v2,?v1)
```

Basically, this SWRL rule allows to compute the distance that separates 2 vehicles, and checks if this distance is smaller than a threshold (*isFollowingParameter*) to infer if a vehicle is following the other one. The other rules which define spatio-temporal relationships between entities follow the same reasoning.

Concerning the future behaviours of the moving entities, the rules have been defined according to the French traffic laws. Basically, a vehicle that is about to reach a stop intersection has to stop at the intersection, a vehicle that is reaching a pedestrian walking on the road has to stop, etc. The rule written for the stop intersection can be written as follows in the SWRL format:

```
vehicle(?v1) ∧ StopIntersection(?stop1)
∧ isToReach(?v1,?stop1)
→ hasToStop(?v1,?stop1)
```

Further, some rules were defined to take into consideration chain reactions which can happen in road situations. For example, a vehicle that is following a vehicle which has to stop, has to stop as well in order to avoid collision.

D. Evaluation with a Hand Written Context

The ontology described in the previous sections has been edited in Protege which enables to edit SWRL rules. The context described in Fig. 4 has been stored in the ABox of the ontology. It contains 3 vehicles going towards a stop intersection. The green car is the closest to the intersection, and just passed a pedestrian crossing with a nearby pedestrian (which is not on the crossing). The red car goes towards the pedestrian crossing, and the blue car is following the red car. The maximum allowed speed on the road is 50km/h. As explained in Section IV-B, the ABox has to contain 4 mandatory individuals: 1 for the subject vehicle (considered here as the blue vehicle), and 3 for the spatio-temporal parameters. For this example, the *isCloseParameter* was set at 3m, and the *isFollowingParameter* and the *isToReachParameter* were set as dependent of the speed limit. It was set that a vehicle is considered to be following another vehicle if it stays behind it within 3s (42m at 50km/h), and that it is about to reach a static entity if at constant speed it is reaching the entity within 5s (70m at 50km/h).

In Protege, the Pellet reasoner was used to reason on the proposed ontology since it allows to reason on SWRL rules.

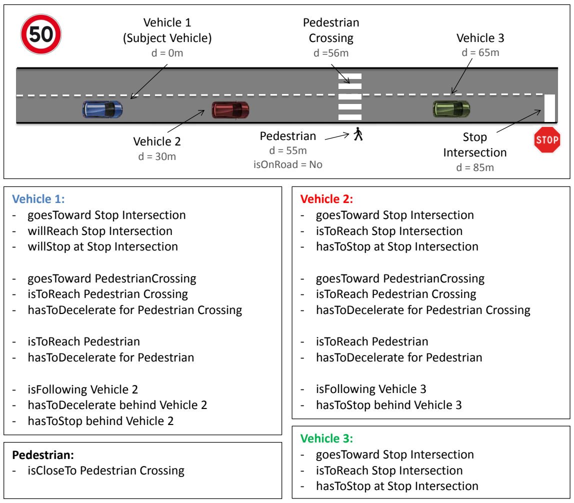


Fig. 4: Evaluation of the inferences of the ontology. On the top, the context chosen for the evaluation. Below, the inferences of the ontology for each mobile entity of the context.

Fig. 4 displays all the ontology inferences for each mobile entity (boxes under the drawing). We can notice that the ontology infers that :

- The pedestrian is close to the pedestrian crossing. It means that he may cross the road on the pedestrian crossing, therefore every vehicle about to reach the crossing has to decelerate and to take care of the pedestrian.
- The vehicle 3 (green) is at 20m from the stop intersection (smaller than the *isToReachParameter* set at 70m), that means that it is about to reach it, and thus that it has to stop at the intersection.
- The vehicle 2 (red) is at 25m from the pedestrian and the pedestrian crossing, so it is about to reach them. That means that the vehicle has to decelerate at the approach to the pedestrian crossing. In addition, the distance between the vehicle 2 and the vehicle 3 is 35m (smaller than the *isFollowingParameter* set at 42m), so it is considered that vehicle 2 is following vehicle 3. But the ontology knows that vehicle 3 has to stop at the stop intersection, so the vehicle 2 will have to stop behind the vehicle 3. Finally, since vehicle 2 is close enough to the intersection to say that it is about to reach it, the ontology infers that vehicle 2 has to stop at the intersection.
- The vehicle 1 (blue) is at 30m from the vehicle 2 (red), so it is considered as following it. Vehicle 2 has to decelerate at the pedestrian crossing and to stop at the stop intersection (at first behind Vehicle 3), therefore Vehicle 1 has also to decelerate and then to stop behind Vehicle 2. Finally, Vehicle 2 is not close enough to the stop intersection to consider that it has already to stop, but it is known that it will probably stop in a near future.

This evaluation shows that the presented ontology is able to process human-like reasoning on global road contexts, and not only on pieces of context. The interaction between all the context entities is taken into consideration as well as chain reactions. This means that it is possible to evaluate the impact of the entire perceived context on each mobile entity, and thus to be aware of their expected behaviours in the future.

V. Real Time Application For ADAS

It is proposed here to use the ontology reasoning as it would be used in real time as part of the framework presented in [2]. The later expects, as an input, to know the most relevant entities perceived by the vehicle that the driver has to be aware of. Therefore, it is necessary to interpret the information inferred by the core ontology (presented in the last Section) to understand what are the most relevant entities, and how the driver should behave to drive in safe conditions. For this purpose, the core ontology described in the previous section has been extended to make it specific and adapted to the needs of [2].

A. Extension of the Ontology

1) Concept: Instead of using an external system that interprets the inferences of the ontology, it has been preferred to directly extend the ontology proposed in Section IV. Additional classes and axioms have been introduced in the ontology. The idea is that, when the ontology infers that the subject vehicle has to be aware of particular entities, it infers a class equivalence between the subject vehicle Individual and one/some of the additional classes.

2) Additional classes: These classes represent the contextual entities that the driver of the subject vehicle should be aware of, and their situations. Currently, only pedestrians, vehicles and stop intersections have been implemented in the ontology, as shown in Fig. 2 (green box in Box 1).

3) Additional class equivalences axioms: It consists only in defining, for every new class, the axiom which make a subject vehicle individual be an instance of one or of several additional classes. For example, it is specified that an instance of vehicle that has to stop at a stop intersection belongs to the class “Stop intersection ahead”. With this information, the framework presented in [2] infers that it has to check that the driver is aware of the stop intersection. Moreover, a vehicle which is following a car that has to stop to let a pedestrian cross the road belongs to the class “Pedestrian before 1 leader”. It means that the driver of the vehicle has to be aware that, because of the pedestrian, the leading vehicle will stop.

B. Experimental setup

A passenger vehicle was used for the experimental part driven on closed roads. A set of perception sensors is installed on the vehicle, and enables to measure the position of a preceding vehicle and of pedestrians. Static entities such

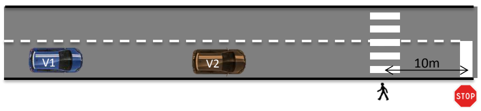


Fig. 5: Scenario chosen for the evaluation of the application for ADAS. Two vehicles (the subject vehicle V1 in blue, the leading vehicle V2 in orange), a pedestrian, a pedestrian crossing and a stop intersection.

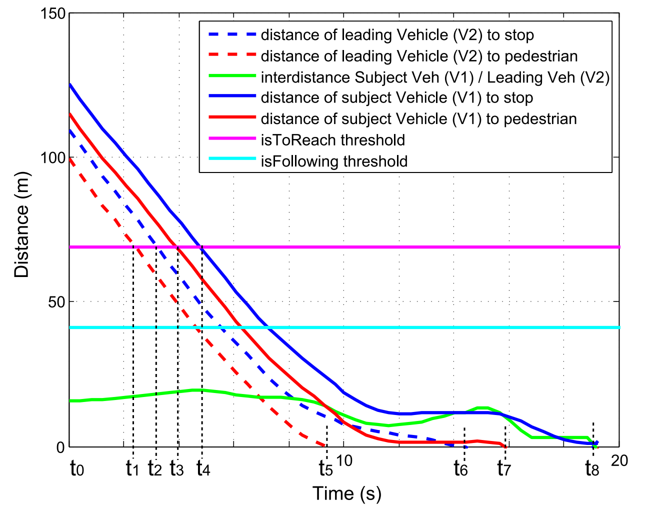
as stop intersections, or pedestrian crossings were stored in an Open Street Map map that was used for the generation of the electronic horizon. The vehicle position was estimated from an automotive type GPS receiver running at 2Hz. All the perceived context entities are stored in the A-Box of the ontology. The Pellet reasoner was used for inferences, through the OWL-API Java library. Reasoning is carried out at every update of the ontology, i.e. at the frequency of the GPS receiver.

C. Results

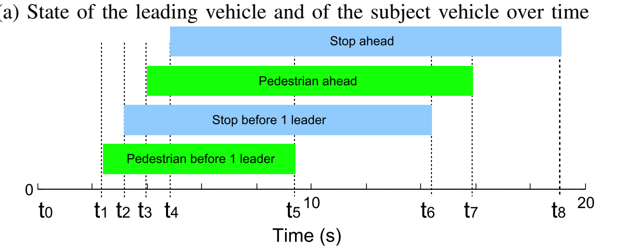
The proposed use case consists of the scenario presented in Fig. 5. The subject vehicle V1 is following another vehicle V2, and both are going towards a pedestrian standing next to a pedestrian crossing (who may have the intention to cross the road), a few meters before a stop intersection.

It is proposed to observe the situation of each mobile entity of the context, and to see how the ontology inferences evolve over time. Fig. 6a presents the situation of the leading vehicle and of the subject vehicle. Fig. 6b presents the classes equivalences of the subject vehicle individual over time, after reasoning. From the point of view of the subject vehicle, the situation evolves through 8 main events (from t_0 to t_8):

- At t_0, V1 is close enough to V2 to say that it is following V2. However, both vehicles are too far from the pedestrian and the stop intersection to start taking them into consideration. No class equivalence appear for the subject vehicle.
- At t_1, V2 becomes close enough to the pedestrian to say that it is about to reach him/her (within 5 sec at constant speed). However, V1 is following V2, so the ontology infers that the driver of V1 has to be aware that V2 may have to decelerate or to brake to let the pedestrian cross the road. The pedestrian is the key entity. Therefore, the ontology infers that the subject vehicle is an instance of the “Pedestrian before 1 leader” class.
- At t_2, V2 becomes close enough to the stop intersection to say that it is about to reach it (within 5 sec at constant speed). V1 has to be aware that V2 has to stop at the intersection, therefore the stop becomes a key entity. V1 is an instance of the “Stop before 1 leader” class. Moreover, V2 has not passed the pedestrian, so it remains a key entity.
- At t_3, V1 becomes about to reach the pedestrian standing next to the pedestrian crossing. The ontology infers that V1 has to be aware that it may have to decelerate to let the pedestrian cross. Therefore, it is inferred that V1 is an instance of the “Pedestrian ahead” class.
- At t_4, V1 becomes about to reach the stop intersection. The ontology infers that the driver of V1 has to be aware that he will have to stop at the intersection. Therefore it is inferred that V1 is an instance of the “Stop ahead” class.
- At t_5, V2 passes the pedestrian, as a consequence, V1 is no longer following a vehicle that has to decelerate or brake for a pedestrian. Therefore, V1 is no longer an instance of the “Pedestrian before 1 leader” class.
- At t_6, V2 passes the stop intersection. Therefore, V1 is no longer following a vehicle that has to stop at a stop intersection. As a consequence, V1 is no longer an instance of the “Stop before 1 leader” class.
- At t_7, V1 passes the pedestrian that did not decide to cross the road. Therefore, it no longer belongs to the “Pedestrian ahead” class.
- At t_8, V1 reached the stop intersection. After t_8, V1 does not perceive any more entity, therefore the ontology does not infer any more class equivalence for V1.



(a) State of the leading vehicle and of the subject vehicle over time



(b) Class equivalences of the subject vehicle after ontology reasoning

Fig. 6: State of the contextual entities over time and ontology inferences

It is noticeable that the subject vehicle can belong to several classes at the same time. It may belong to 2 classes which refer to a same context entity (for instance “Pedestrian ahead" and "Pedestrian before 1 leader"), but this provides guidelines to the algorithms exploiting the ontology inferences.

The average processing time for reasoning on the ontology was 71 ms for this scenario, on a laptop running Windows7 with 4Gb RAM and a 1.9 GHz Intel Celeron processor.

D. Discussion

The evaluation of the proposed ontology has shown that ontologies can be used as a powerful tool to reason on road contexts. Most of conventional ADAS solutions, for contexts studied in the last paragraphs, would have taken contextual entities as independent entities. For example, for the context of Fig. 5, the leading vehicle only would have been taken into consideration, without anticipating its behaviour knowing that it is about to reach a pedestrian and a stop intersection. The pedestrian would have been relevant from the point of view of a conventional ADAS only once the leading vehicle passed it.

As explicitly mentioned in the former parts of the paper, the proposed ontology was not designed to be able to reason on any context. It can only reason on contexts compatible with it, i.e. contexts which only meet entities which have been defined in the TBox. This means that for an intensive use of the ontology, it has to be extended to take new types of entities into consideration. New rules also have to be defined. However, the ontology should be extended sparingly because the heavier an ontology, the longer it takes to reason on it.

The time necessary to reason on an ontology is quite significant and has to be taken into consideration. For real time applications, reasoning on the ontology should be carried out asynchronously with the rest of the system, as done in [13].

VI. Conclusion

An ontology that provides a description of entities regularly met in drivable spaces has been presented. It enables to perform human like reasoning on road contexts as they can be perceived by passenger vehicles. The interaction between all contextual entities and chain reactions are taken into consideration to understand the influence of the whole context on a subject vehicle. The ontology has been used to reason on real road contexts in order to provide information to an ADAS system. For this task, real data recorded on a passenger vehicle has been used. This evaluation has shown real time capabilities and a coherent understanding of the perceived context (through the perceived context entities). It makes it possible to understand what the key context entities are, for better ADAS situation awareness.

Further work will consist in using ontology inferences as an input to the framework presented in [2] for a real time estimation of the driver context awareness, with respect to context entities. Thus, the contribution of additional knowledge about the context for ADAS will be evaluated.

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