Artificial Intelligence

Pedestrian Ontology

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THE CONTEXT

Road traffic injuries are a leading cause of death globally

Each year almost **1.2 million** people die on the roads

49% of all road traffic deaths occur among the weakest categories of road users (pedestrian, cyclist and motorcyclist)

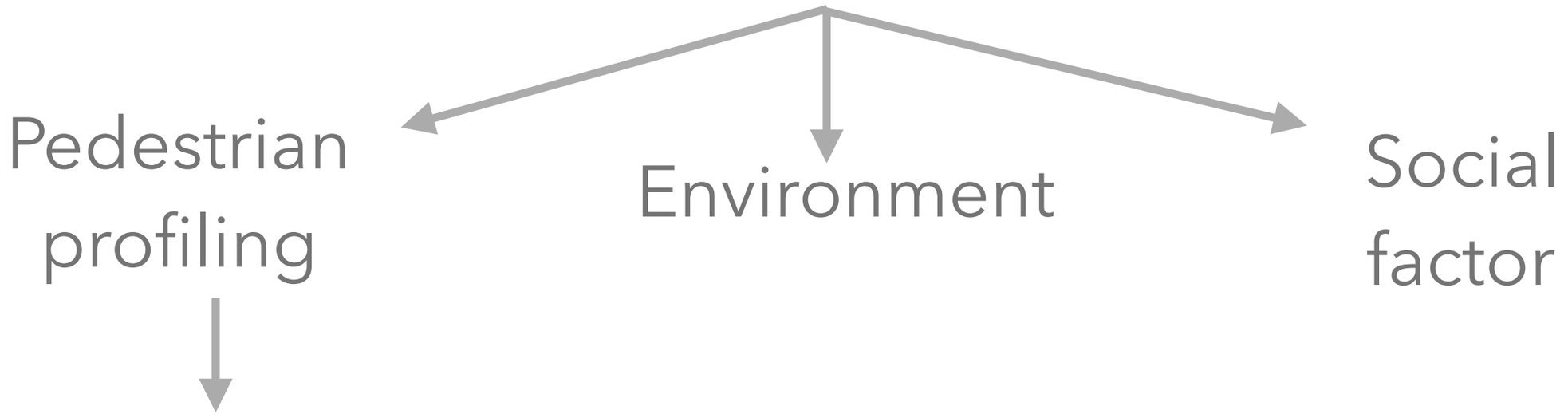
22% of road traffic dead in the world (**26%** in Europe, **16%** in Italy) are pedestrians.

Source: Global Status on Road Safety 2015 - World Health Organization

THE CONTEXT

Need to improve road safety in the cities of the future

Possible solution: **SELF DRIVING CARS**



High complexity
Lots of variables
High nondeterminism

PROPOSED SOLUTION

We propose an **ontology** which describes a typical **pedestrian** behaviour and that deals with all the static and mobile entities found on a street.

OUR GOAL is to create the ontology starting from an existing work that faces the same problem from the point of view of the vehicle.

The result of the integration between our ontology and the existing one could be used by the self driving car manufacturers as a representation of the pedestrian and vehicle behaviours during pedestrian crossing situations in order to improve the cooperation between the agents.

AN AGENT PERSPECTIVE - *Goals*

***VEHICLE*:** his goal is to cross the pedestrian crossing in the shortest possible time

PEDESTRIAN: pedestrian goal is to cross the street (without being injured)

Goals compatible, competition for the resources, independence: obstruction

NEGOTIATION NEEDED

P.E.A.S. MODEL

	PERFORMANCE	ENVIRONMENT	ACTUATORS	SENSORS
PEDESTRIAN	Safely cross the street	Sidewalk, vehicles, other pedestrians	Legs, mouth, arms	Eyes, ears, ...
VEHICLE	Avoid collision	Road, pedestrians, others vehicles	Steering, accelerator, brake, …	Cameras, GPS, accelero meter, ...

ASSUMPTIONS

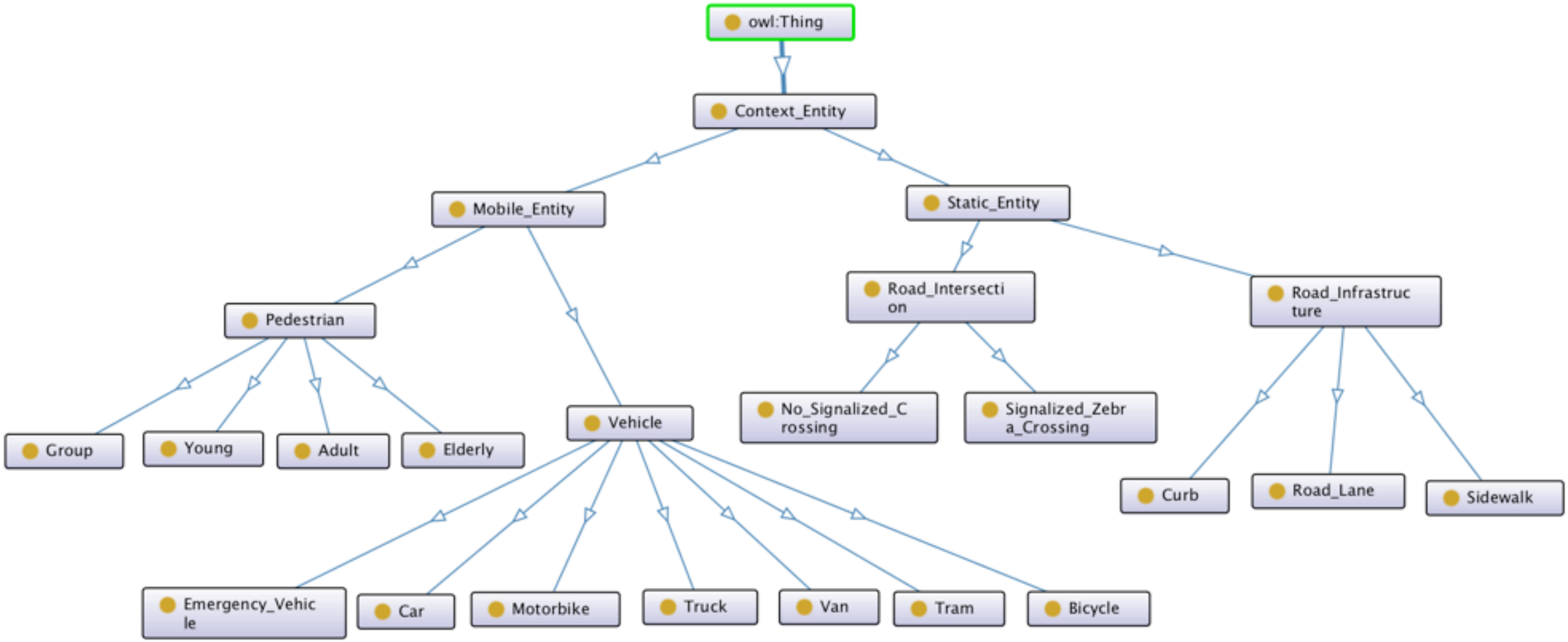
RULE COMPLIANT: respectful of the rules.

Our ontology is based on previous works and researches.

Considering them we assume that:

- all pedestrian are **compliant** with the rules (only one exception)
- the pedestrian crossing is **non-signalized** (as the crossing observed in the considered works is Viale Padova crossing in Milan)
- there is **at most one car** on the road lane
- the **visibility conditions** are the best

PEDESTRIAN TAXONOMY



OBJECT PROPERTIES

- HasToReach
- IsCloseTo
- IsNear
- IsOn
- HasToAccelerate
- HasToDecelerate

DATA PROPERTIES

- Pedestrian:
  - Age
- Vehicle:
  - IsMoving
  - Speed
  - SafetyGap
  - DistanceToZebraCrossingInMeters
- SignalizedZebraCrossing
  - TrafficLight

CROSSING BEHAVIOUR PHASES

- ***Approaching***: the pedestrian walks on the sidewalk with a stable speed

- ***Appraising***: the pedestrian approaching the crossing lines decelerates to evaluate the distance and speed of oncoming vehicles (safety gap)

- ***Crossing***: the pedestrian decides to cross and speed up

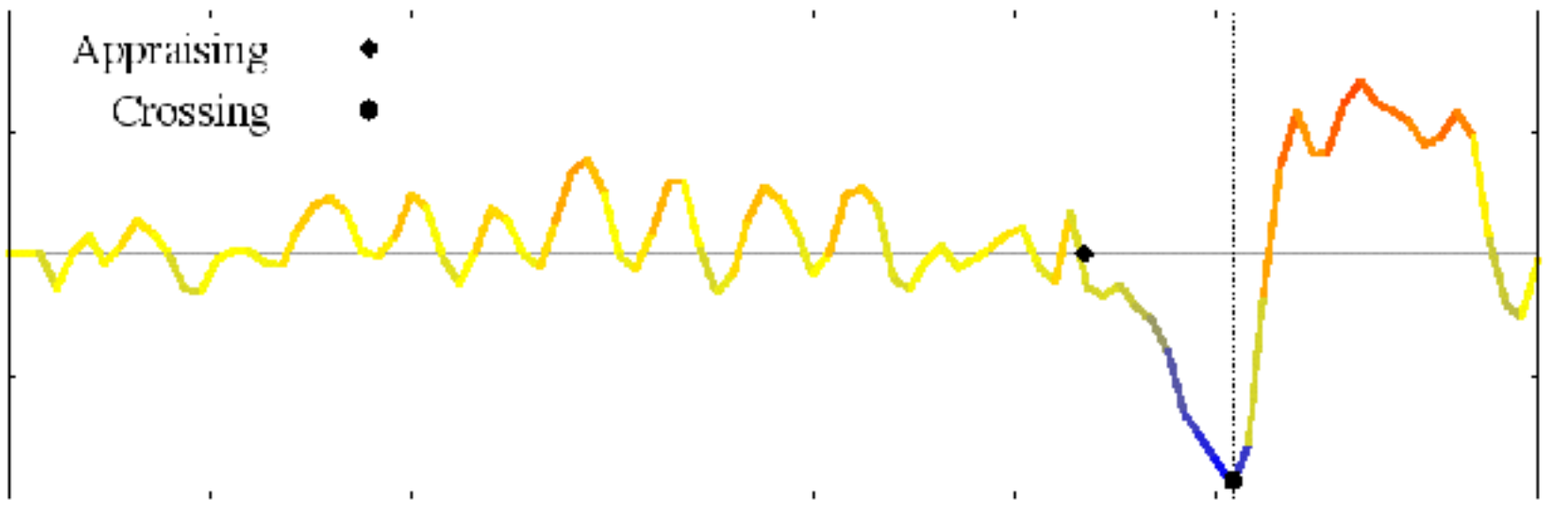
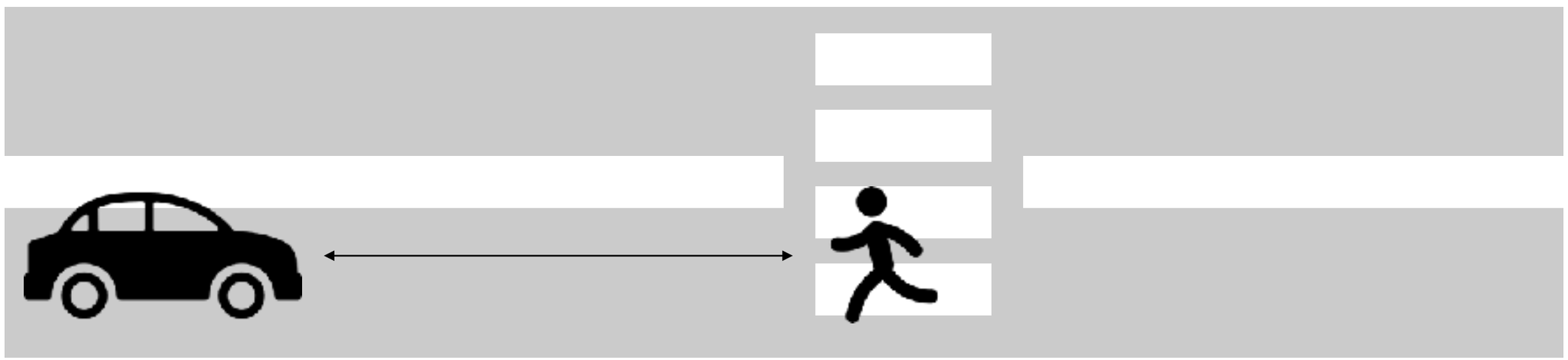


Figure 1. The standard trend of a pedestrian speed along the sidewalk during the crossing behaviour

SAFETY GAP

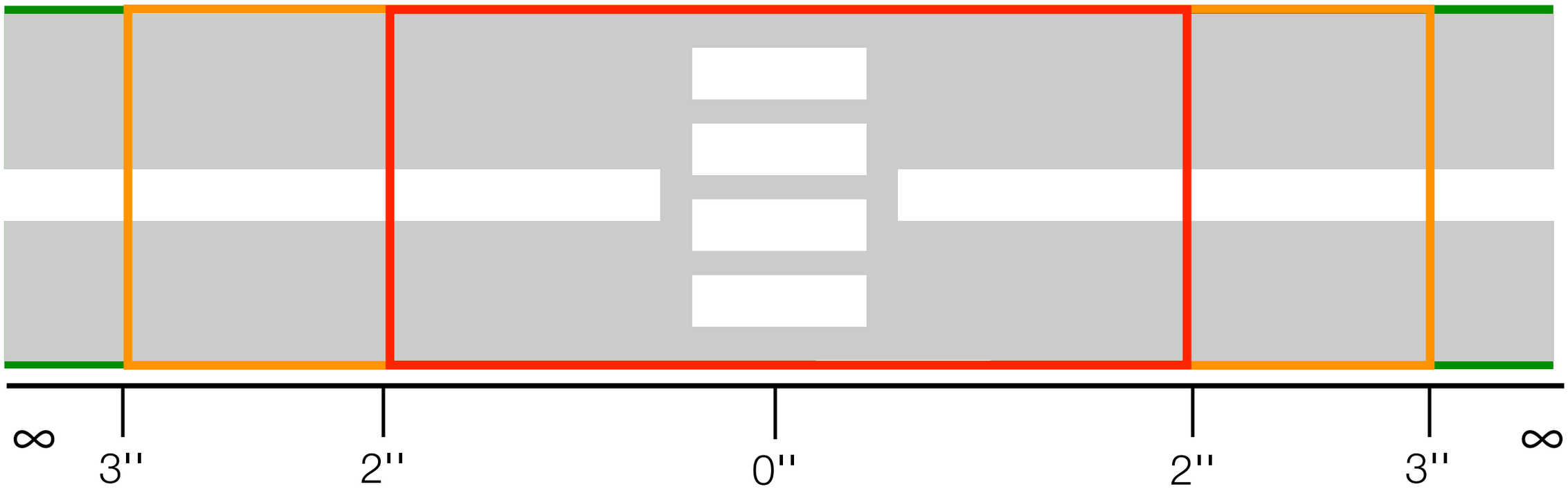
The safety gap is the pedestrians' evaluation of the distance of an approaching vehicle and its average speed (not taking into account acceleration/ deceleration trends) in order to decide if the gap is large enough to pass safely



SAFETY GAP

Safety Gap formula: **Distance[m] / Speed[m/s]**

IsToReach	> 3''
IsCloseTo	2'' < x ≤ 3''
IsOn	0'' ≤ x ≤ 2''



NO SIGNALIZED ZEBRA CROSSING

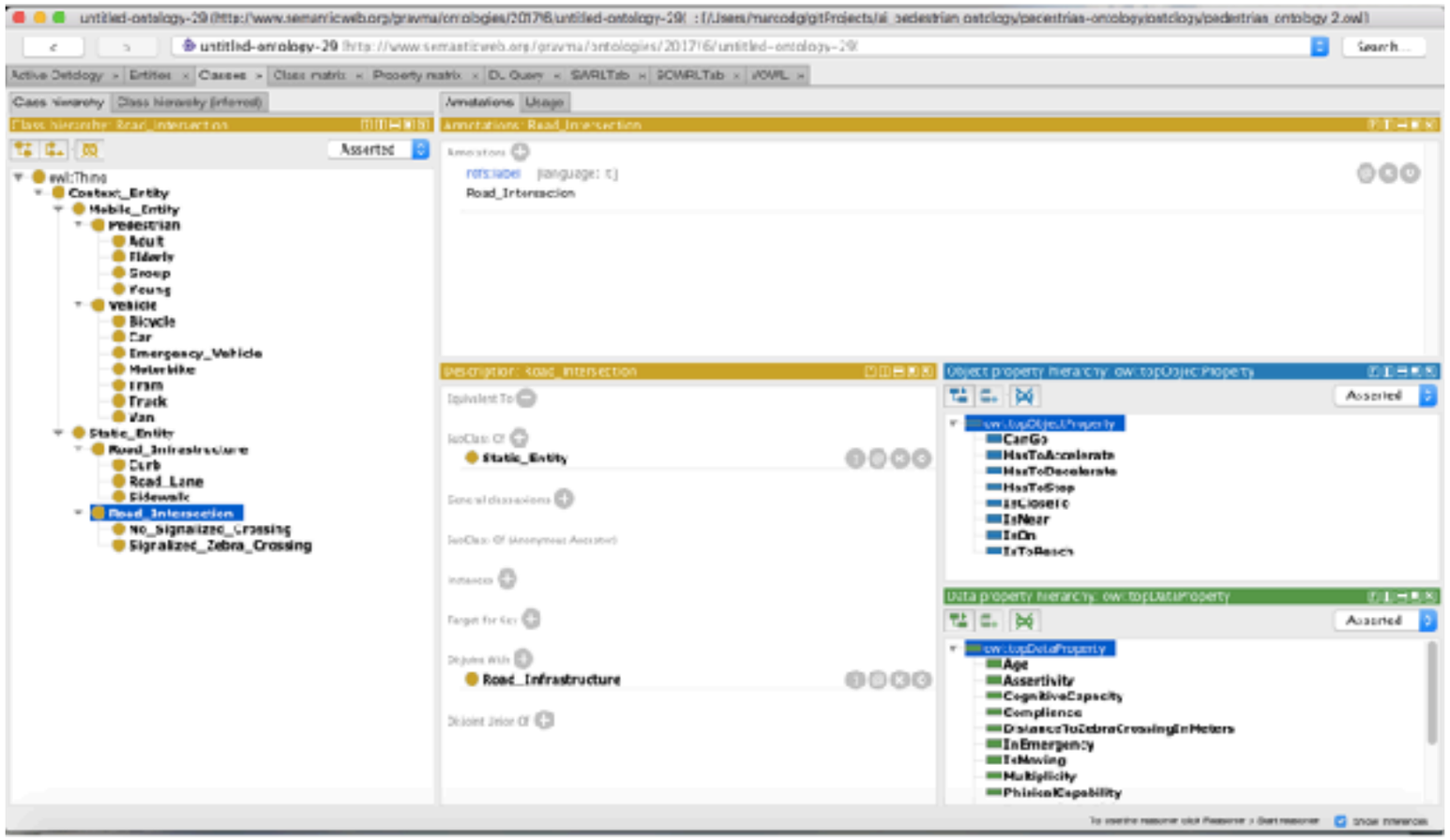
Safety Gap (x)	Vehicle state	Pedestrian Type	Cross
x > 3''	Moving/Stationary	Pedestrian	**CanGo**
2'' < x ≤ 3''	Stationary	Pedestrian	**CanGo**
2'' < x ≤ 3''	Moving	Young/Adult	**CanGo**
2'' < x ≤ 3''	Moving	Elderly/Group	**HasToStop**
0'' ≤ x ≤ 2''	Stationary	Pedestrian	**CanGo**
0'' ≤ x ≤ 2''	Moving	Pedestrian	**HasToStop**

SIGNALIZED ZEBRA CROSSING

Safety Gap (x)	Pedestrian Type	Traffic Light Color	Cross
x > 3''	Young	Red	**CanGo**
x ≥ 0''	Adult, Elderly, Group	Red	**HasToStop**
0'' ≤ x ≤ 3''	Young	Red	**HasToStop**
x ≥ 0''	Pedestrian	Green	**CanGo**
x ≥ 0''	Adult/Young	Yellow	**CanGo**
x ≥ 0''	Elderly/Group	Yellow	**HasToStop**

THE TOOL: *Protégé* (*)

Protégé is a free ontology editor and a knowledge management system. It provides a graphic user interface to define ontologies and includes deductive classifiers to validate that models are consistent and to infer new information based on the analysis of an ontology.

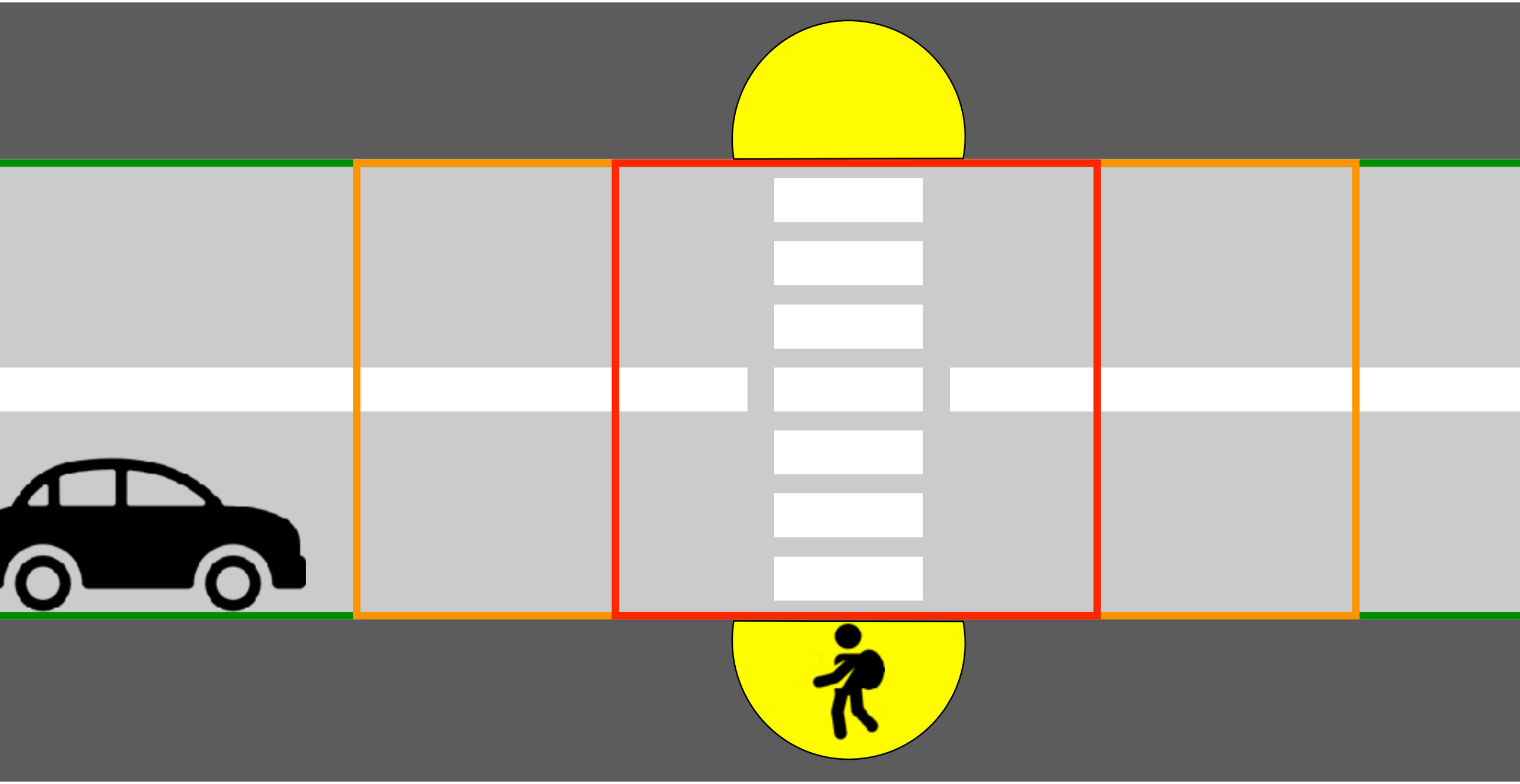


(*) Open source tool available at: https://protege.stanford.edu

EXAMPLES

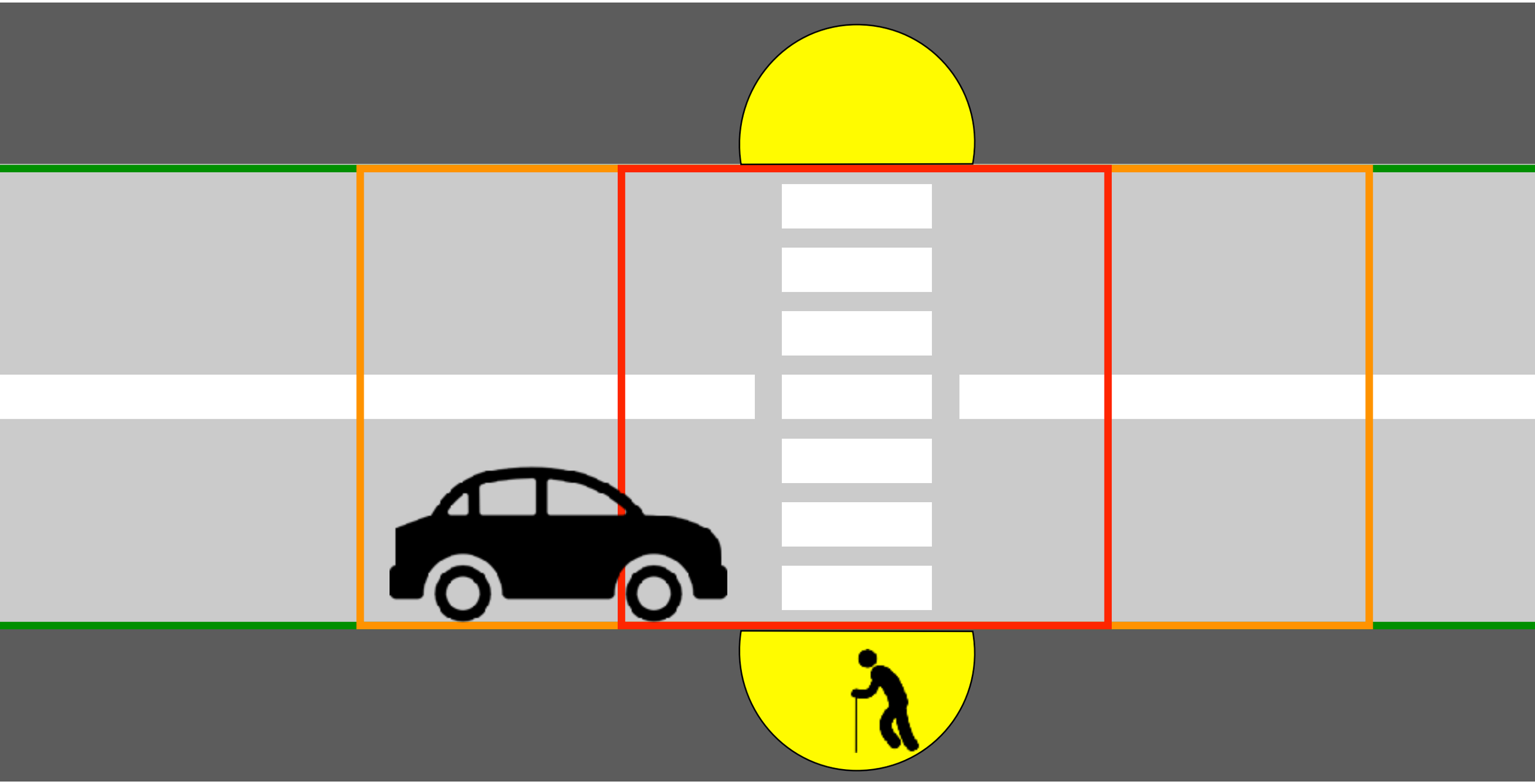
Rule

No_Signalized_Crossing(?nsc), Road_Lane(?rl),IsOn(?v, ?rl), IsOn(?nsc, ?rl), IsCloseTo(?c, ?nsc), Curb(?c), Sidewalk(?s), IsOn(?c, ?s), Pedestrian(?p), **Vehicle**(?v),IsNear(?p, ?c), **IsToReach**(?v, ?nsc) -> **CanGo**(?p, ?p)



Rule

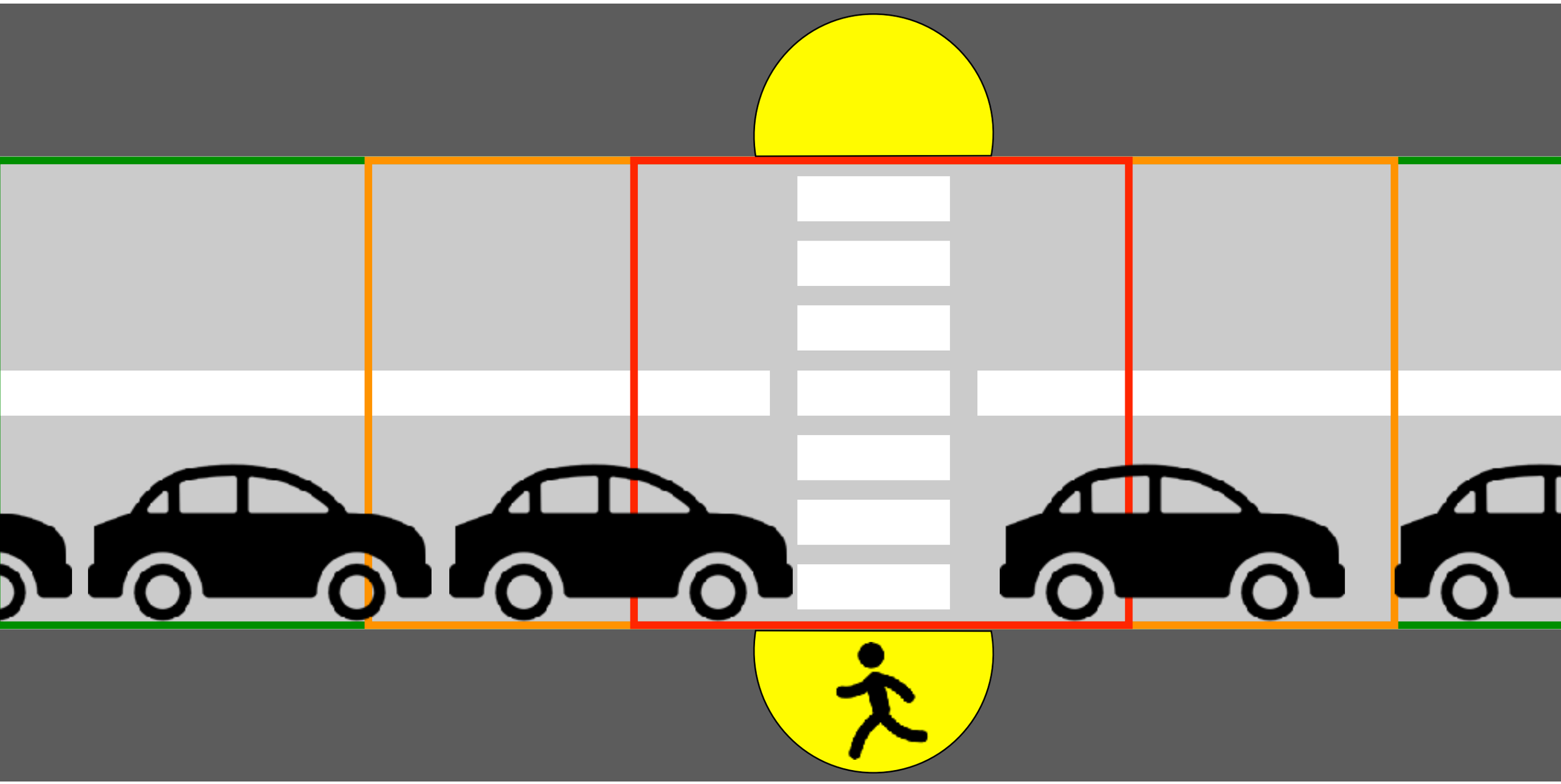
No_Signalized_Crossing(?nsc), Curb(?c),Road_Lane(?rl),
IsOn(?v, ?rl), IsOn(?nsc, ?rl), IsCloseTo(?c, ?nsc),
Sidewalk(?s), IsOn(?c, ?s), Pedestrian(?p),
Vehicle(?v), IsNear(?p, ?c), **IsOn**(?v, ?nsc),
IsMoving(?v, true) -> **HasToStop**(?p, ?p)



Rule

No_Signalized_Crossing(?nsc), Curb(?c), Sidewalk(?s), IsOn(?c, ?s), Road_Lane(?rl), IsOn(?v, ?rl), IsOn(?nsc, ?rl), Pedestrian(?p), **Vehicle**(?v), IsNear(?p, ?c), IsCloseTo(?c, ?nsc), **IsOn**(?v, ?nsc), IsMoving(?v, false ->

CanGo(?p, ?p)



REMARKS

Mereology is the branch of philosophy which studies objects and their parts and the relationships that hold between these parts.

There is disagreement concerning whether teams and other groups should be regarded as genuine mereological wholes. Many are inclined to regard groups as entities of a different sort and to construe the relation of group membership as distinct from parthood.

Group:

- Modelling as a single entity
- Modelling as a pedestrian category

REMARKS

- ***Emergency vehicle***: The idea is that if there are some emergency vehicle (in state of emergency) the situation is frozen: the vehicle passes before anyone
- ***Bicycle lane***: Now it is considered as a part of the street, but if considered separately, the pedestrian must pay attention to the bicycle on the lane and then to the vehicles on the street

REMARKS

- ***Obstacles***: the presence of obstacles can change trajectories of the pedestrians (jaywalking) and also their speed

- ***Sidewalk condition***: could change walking path of the pedestrian

- ***Traffic police man***: in some cases like a traffic light, in other situations can freeze the situation (e.g. car accident)

- ***Horizontal signs***

- ***Pedestrian crossing visibility***

PROBLEMS

- There are many reasoner implemented in different way (Pellet over HermiT)
- Some rules work with a reasoner but don't with another one
- Problem with rules priority
- Impossible to show continuous scenarios with Protégé, it works with "snapshots"

CONCLUSIONS

- Open Problems
  - Replace humans interaction (e.g. driver's hand gesture used to tell pedestrian can cross)
- Further Innovations
  - Integration with vehicle ontology (discussed above)

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