Fuzzy Ontology Based Model for Supporting Safe Driving

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Summary
In developing countries like Vietnam, the number of cars is increasing rapidly, new drivers are getting more and more and have no experience handling traffic situations. A system which simulates traffic situations will support new drivers to handle traffic situations expertly. One of the most important information sources in this kind of systems is sensors. Sensors can be within vehicles or as part of the infrastructure such as lanes, roads, traffic signs, etc. Sensors can provide information related to weather conditions and traffic situation, which is useful to improve the driving process. This paper based on fuzzy ontology to build a simulation system aim to support drivers. This system is tested with four situations and gives good results.

Key words:
Ontology, Fuzzy Ontology, Simulation, Fuzzy Inference

1. Introduction

In computer science, an Ontology [1] is a data model that represents a field and is used to reason about objects in the field and the relationship among them. The ontology definition is divided into four main concepts: abstract description of phenomena (perception), explicit expression in mathematics (form), concepts and relations among them must be defined clarity, there exists a consensus of ontology users. The ontology includes the following main components: Entities, Classes, Attributes, Relationships among Concepts or Entities. An ontology architecture is shown in Figure 1.

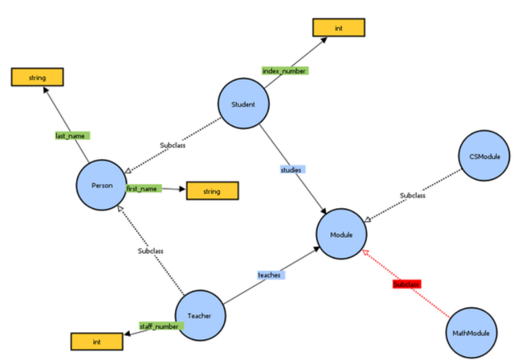

Fig. 1 Ontology Architecture

According to David Parry [2] fuzzy ontologies are based on concepts in which each item, each element or object is related to other item, component (or object) in the ontology with a degree of fuzzy defined based on Fuzzy Logic introduced by Zadeh [3]. The fuzzy degree of the membership function is denoted by μ, in which 0 <μ <1, and μ corresponds to a fuzzy relation such as "strongly", "partially", "somewhat" and "slightly". A fuzzy ontology architecture is shown in Figure 2.

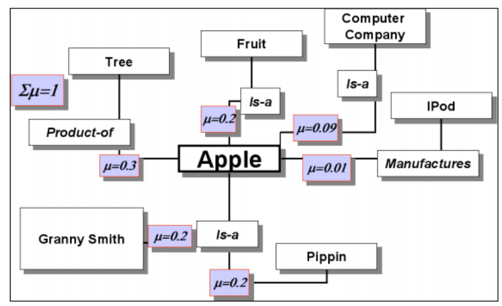

Fig. 2 Fuzzy Ontology Architecture

In fuzzy ontology above, Apple can be product of tree because of the relationship “Product of” with μ=0.3, or Apple can also be Fruit because of the relationship “is-a” with μ=0.2. Different relationships will have different membership function values depending on the context. Fuzzy ontology represents knowledge in all fields, in which the concepts represented have fuzzy definitions. These fuzzy concepts are referred to as fuzzy sets. Any entity does not completely belong to or does not belong to any fuzzy definition but it has a membership function value that represents the entity of that concept.

In the last years, there has been an increasing interest in ontologies for road transportation systems. According to [4], an ontology to represent traffic in highways has been developed. Ontologies provide a common vocabulary in a given domain and allow defining, with different levels of formality, the meaning of terms and the relationships between them [5]. Ontologies facilitate the design of exhaustive and rigorous conceptual schemes to allow communication and information exchange between different systems and institutions.

Ontology in the road traffic system is considered the ontology of road traffic and road traffic situations. Ontology on traffic situations is used to describe traffic situations but also directly supports traffic situations such as a model that is closely linked to vehicles. The ontology describes the relative position of a vehicle on the road, possible situations of a parking lot or public transport. A traffic ontology architecture is shown in Figure 3.

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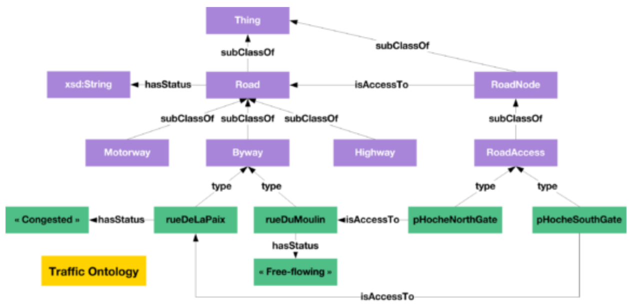

Fig. 3 Traffic Ontology Architecture

This paper proposed an ontology model to build a simulation system for supporting to warn drivers. The main contributions of this paper focuses on the following sections:

- Building Ontology model.
- Building fuzzy inference model.
- Designing a simulation system by C# to test with four situations.

The rest of the paper is structured as follows. The proposed model is described in detail of Section 2. Section 3 presents the simulation system. Section 4 gives conclusions and outlines future research directions.

2. Proposed Model

Proposed model is designed with ontology model, relationships and classes of ontology as follows.

2.1 Proposed Ontology

The proposed Ontology is built with the following entities such as vehicle, lane, road, time, weather, human, traffic signal and shown in Figure 4.

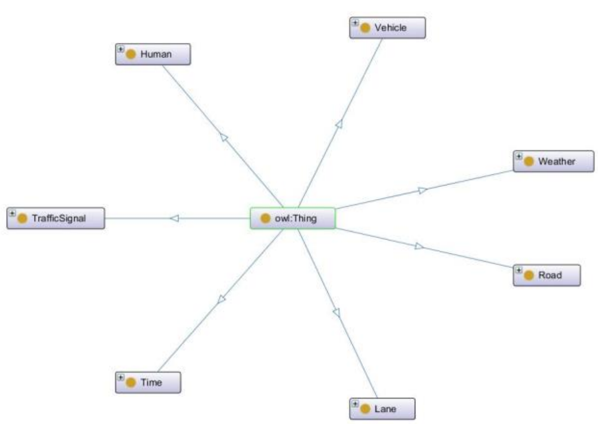

Fig. 4 Proposed Ontology

2.2 Ontology Relationships

The Relationships of Ontology are shown in Figure 5.

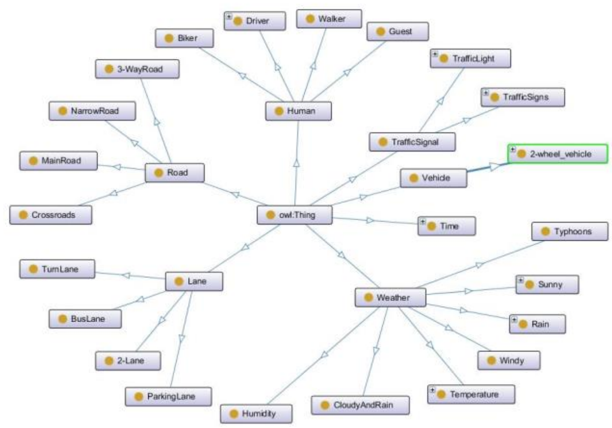

Fig. 5 The Relationships of proposed Ontology

2.3 Classes of Ontology

The basic classes of Ontology are shown in Figure 6.

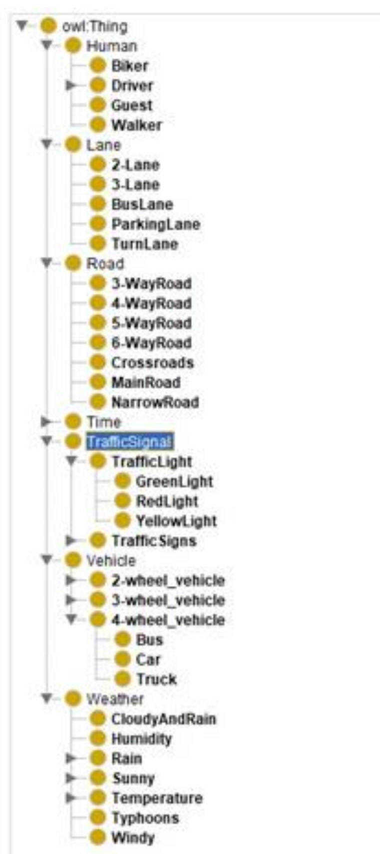

Fig. 6 The basic classes of proposed Ontology

2.4 Fuzzy Ontology Model

Building membership functions for linguistic variables as follows:

- Speed includes labels such as Slow, Average, Fast (*v*). Figure 7 describes membership function for "Speed" linguistic variable.

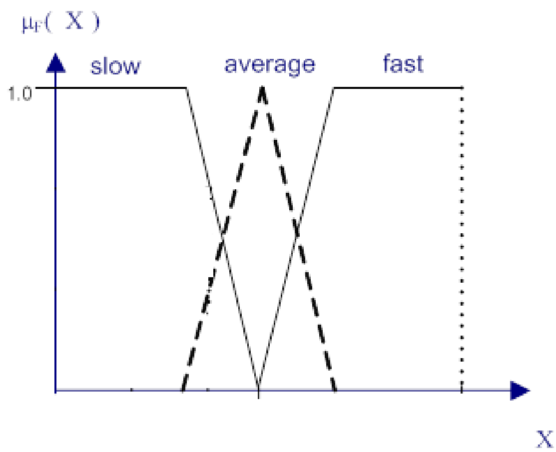

Fig. 7 "Speed" linguistic variable

- Distance from vehicle to intersection includes labels such as danger, near, medium, far (*d1*).
- Distance from vehicle to left-hand lane includes labels such as danger, near, medium, far (*d2*).
- Distance from vehicle to right-hand lane includes labels such as danger, near, medium, far (*d3*).

Figure 8 describes membership function for "Distance" linguistic variable.

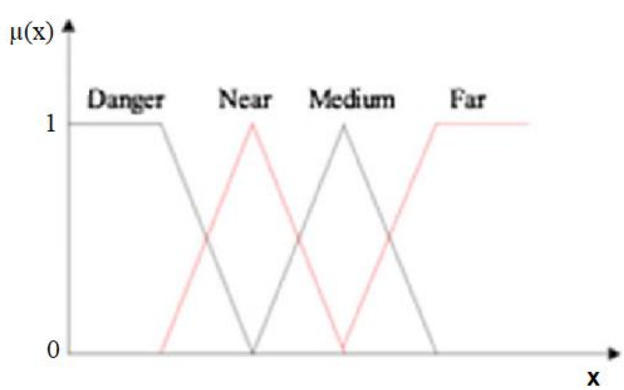

Fig. 8 "Distance" linguistic variable

Fuzzy ontology model is shown in Figure 9. This model gets the values *v*, *d1*, *d2*, *d3* from sensors and make decision to support drivers.

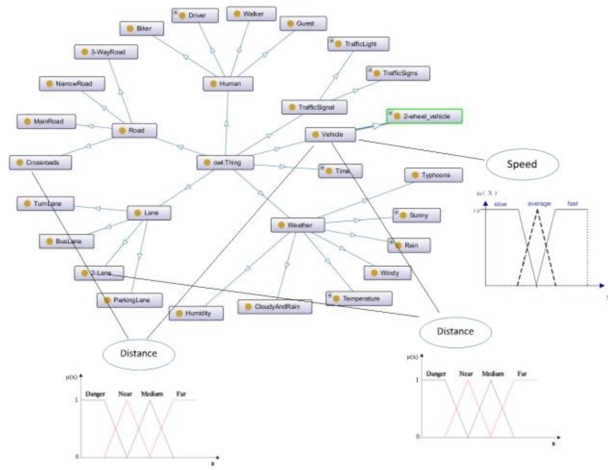

Fig. 9 Fuzzy Ontology Model

3. Simulation

This simulation system is built on Unity 3D software [6] and written in C # language, combined with the emulator steering wheel "Logitech G29 Driving Force Racing Wheel" [7]. Figure 10 describes the simulation system.

Fig. 10 Simulation System with Logitech G29 Racing Wheel

The following are 4 simulation situations which support to warn drivers.

3.1 The First Situation

This situation warns drivers when going over speed. The simulation system displays a notification to warn the driver as shown in Figure 11.

Fig. 11 Simulation System warns "Over Speed"

3.2 The Second Situation

This situation warns drivers when getting in the left-hand lane. The simulation system displays a notification to warn the driver as shown in Figure 12.

Fig. 12 Simulation System warns "Getting in the left-hand lane"

3.3 The Third Situation

This situation warns drivers when getting in the right-hand lane. The simulation system displays a notification to warn the driver as shown in Figure 13.

Fig. 13 Simulation System warns "Getting in the right-hand lane"

3.4 The Forth Situation

This situation warns drivers when coming soon to an intersection. The simulation system displays a notification to warn the driver as shown in Figure 14.

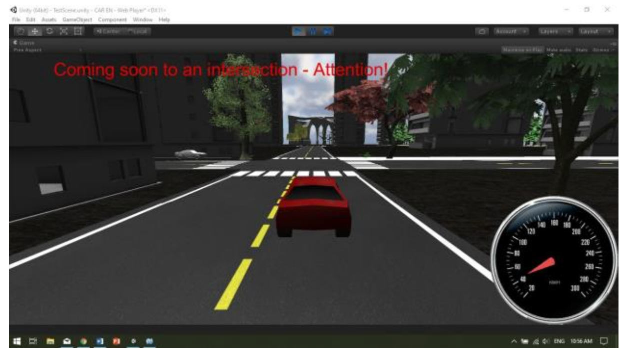

Fig. 14 Simulation System warns "Coming soon to an intersection"

4. Conclusion

This paper proposed a fuzzy ontology model for supporting safe driving. A simulation system based on the above mentioned model is written in C # language on Unity 3D software with the emulator steering wheel "Logitech G29 Driving Force Racing Wheel". This proposed system is tested with four situations and gives good results with multiple test driving on the system. In the future, our team will test more than with mentioned-above four situations and new situations to evaluate the system to be applicable in practice.

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