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A Semantic Agent-Based Safety Model for Alzheimer's Patients for Driving

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ABSTRACT: Alzheimer's disease drastically affects the human neurological system, causing the death of neurons and synapses in cerebral cortex and other regions. Consequently, patients with Alzheimer's disease require 24/7 care and assistance with daily life activities. This study uses an ontology-based semantic model to assist the Alzheimer's patients through activity recognition in the focused scenario of driving. The safety model presented in this paper alerts the user if anything dangerous is about to happen when they enter a car or during driving. It should be noted that the model is specifically designed for the patients suffering from a mild form of Alzheimer's disease. We have used semantics to define the objects and environment for the patients. After proper monitoring and evaluation, our model suggests a proper course of action based on semantic reasoning.

INDEX TERMS: activities of daily living, cognitive impairment, domain ontologies, semantic reasoning

I. INTRODUCTION

Alzheimer's disease, commonly known as AD, is an exceptionally hazardous neurological illness. Early indications of AD include a momentary loss of memory, confusion, critical issues with language, time disorientation, withdrawal from work and from different social exercises, enthusiastic disinterest, and various other conditions. Alzheimer's disease affects the neurological framework as it is a neurodegenerative disease. Moreover, it generally affects the lifestyle of the patients as well. This paper distinguishes and assesses the impact of Alzheimer's disease on other life function [1].

Alzheimer's disease exists even in the 21st century because the assessments of the scientists concerning the fundamental drivers of this disease fluctuates undeniably [2]. For example, most of the scientists recommend that hereditary qualities pose a significant risk factor that invigorates the turn of events and movement of Alzheimer's disease. Moreover, according to

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previous research, 80% of factors leading to Alzheimer's are characterized as hereditary up to 80% [3].

Alzheimer's disease drastically affects the neurological system of human beings, causing the death of neurons and synapses in cerebral cortex and other regions. The patients of this disease require 24/7 care, so that they may live their life properly. For them, living their life independently becomes a very difficult task. Even accomplishing a simple task like driving also becomes a challenging ordeal for these patients.

For this reason, we aim to propose an ontology-based semantic model that assists patients before and during driving. Through this model, the patients' activities are recognized and based on standard danger levels scales be assessed and if any the patient will be notified.

II. Related Work

Alzheimer's disease remains an area of interest for researchers because of the number of people affected by it over the years. Investigation concerning Alzheimer's are made over the variety of factors, symptoms and impacts for the diagnostic and treatment.

The current paper focuses on the people with mild dementia, for whom driving is a high-risk activity. The main aim of this project is to devise a cognitive test that can predict the driving ability of these patients. Data was collected from 28 drivers with dementia and 28 healthy elderly patients. After proper research and evaluation, the researchers concluded that there is a strong correlation between driving performance and the performance based on specific cognitive tests [4].

A common trait of Alzheimer's or intellectually impaired patients is their inclination to experience spatial and fleeting confusion, which causes them to get lost. To avoid this problem, caregivers should utilize GPS gadgets to locate and keep tabs on the patients in a discrete manner.

Based on the data taken from administrative healthcare projects and organizations that observe Alzheimer's patients, and also from geo-area specialist co-ops, the current research encourages the use of GPS gadgets by specialized caregivers to monitor Alzheimer's and intellectually impaired patients. Thus, this paper suggests the use of GPS tracker for Alzheimer's patients 24/7, so that their whereabouts can be monitored properly.

It has been noted that a large number of Alzheimer's patients suffer from agitated behaviour, which may create a stressful work environment for their caregivers. A number of AI-based technologies have been designed to manage this agitated behaviour in Alzheimer's patients, but it came inappropriate prediction models and misleading data representation became a challenge in them. So, this paper proposes an ontology-based coding model for managing the agitated behaviour of the Alzheimer's patients. The study here came up with Dementia-Related Agitation Non-Pharmacological Treatment Ontology (DRANPTO). The method used by it is the Neon methodology [5]. Through this study, it has been deduced that DRANPTO can come up with better knowledge representation and standardization. It can successfully communicate with the readers about the disease related medical domain concepts and their relationships [6].

The current paper describes another methodology that depends on propositional analytics to isolate complex occasions that can be interpreted through semantic thinking derived from occasions that require data beyond semantic engine's own understanding. Regression analysis was used to evaluate the response time and the study concludes that response time of the systems to identify and notify the danger level is tolerable.

This paper showcases the difficulties in creating a semantic-based Dementia Care Decision Support System used to check discretely a patient's conduct. It should be noted that semantic-based methodologies are appropriate when there are dynamic behaviour observations as seen in Dementia care frameworks, hence the patients' powerful conduct perceptions (user's area, objects used) should be investigated against the semantic information available about their condition (disease history). The current paper reveals the capacity of semantic innovations to reason based upon complex interrelated occasions that originate from the conduct checking sensors used to gather information [7-10]. There has been a lot of work done in the domain of ontologies using Big Data [11], Blockchain [12], and drug interaction models [13, 14]. Also, ontologies are very important in the domain of Natural Language Processing (NLP) [15-18]

III. EXAMPLE USAGE

To exemplify the usage of our model, we have used a driving scenario in which the patient is suffering from a mild case of Alzheimer's disease. The location for the scenario is a road and a room where equipment related to driving is kept. While driving, the patient needs to carry home keys, car keys, a mask, and sanitizer due to the present COVID-19 regulations.

Dividing the location into zones helps in the proper documentation of the patient's activities and deducing danger levels. In this study, there are two zones: a room where keys, masks, and sanitizer are kept and a road where the patient will drive.

The scenario is of the patient going to a nearby park for a walk. However, the park is at least 5 miles away, so the patient needs to drive to get there.

Now, for this hypothetical scenario, the patient needs to carry home keys, car keys, mask, sanitizer and a water bottle (optional). Our model analyses the actions of the patient. It checks if the user has taken along the home keys, car keys, and a mask. If the patient has not taken these items, the danger level rises. As soon as the system gauges that the patient has taken all these things, the danger level decreases. If the patient forgets to take along these items, an alert is generated. Afterwards, when the patient sits in the car, another alert is generated to let the patient know whether the lights in the car are on or off based on the situation. Similarly, another alert is prompted to check the temperature in the car. Some alerts are generated to warn the patient when they exceed a certain speed limit, while others are generated when the patient is near the traffic signals. Through our safety model, the patient is notified about the traffic light and told to take an action based on the corresponding traffic signal. Similarly, an alert can also be generated to urge the patient to check if the hand brake is down or not as soon as they enter the car.

A. Scenario to Address

For this analysis, we assume that the patient is using the sensors affiliated with Alzheimer's patients to detect things. We also assume that the patient is wearing a wearable device such as a watch. Our ontological approach to activity recognition and danger assessment uses a scenario in which an Alzheimer's patient is driving a car and it can be used to assist them with several activities before and during driving. In this particular scenario, we need to address challenges such as the speed of the vehicle, distance from the next car, and distance from a vehicle to the left or right of the car, as well as traffic signals. For example, if the patient reaches a traffic signal, then the sensor in the car should detect which traffic signal is on and which are off. An alert would be sent to the patient's wearable device and also to the car, so the patient can be alerted through the car speakers.

IV. Analysis of Strategy and Tools

The instruments utilized for the execution of this scenario include Protégé, OWL, SWRL, RDFS, the Jena API, and Jess API. These make an Action Driven Model and consequently, make our safety model an Action Service Ontology.

A. Protégé

Protégé is a free open-source stage created by the Stanford University for the development of area models and information-based applications utilizing ontologies [19].

B. OWL

OWL or the Web Ontology Language is a semantic web computational rationale-based language intended to state information about concepts, groups of concepts, and the relationships between concepts. It may be utilized to confirm the consistency of information patterns or to deduce verifiable information (W3C, 2018) [20].

C. RDFS

RDFS or the Resource Description Framework Schema is an augmentation of the fundamental RDF vocabulary that takes into consideration information demonstration. RDF itself is a standard model for information trade on the internet (W3C, 2018). It is used to communicate the rules for semantic web given by SWRL or the Semantic Web Rule Language [21].

D. Jess

Jess Rule Engine is a standard engine for the JAVA platform that can generate new information from pre-set principles.

E. Apache Jena

Apache Jena is an open-source semantic web structure for JAVA that gives an API to separate information from and compose information to RDF diagrams.

F. Pellet

Pellet is an open-source JAVA-based semantic reasoner for OWL2. A semantic reasoner is a program that can derive sensible results from a bunch of declared realities and maxims.

With regard to this paper, Activity Driven Model is characterized as a semantic model that takes into consideration user actions.

Activity Service Ontology is characterized as formal and computable representation of real-life processes for client activities that can be given as a Web Service.

Utilizing the above devices and ideas, a Significance Level Model is proposed that can be executed to support and help with action acknowledgment, give acknowledgment of activities, and respond to them as needed. Utilizing the instrument's accessibility, we can fabricate an OWL model that can be used to portray the environment around the occupant, express the connections between the objects in the environment in RDFS, use SWRL to characterize rules, and Pellet to reason the outcomes. Apache Jena and the Jess Rule engine can be utilized to make new principles and supplement new axioms dependent on user conduct. For Pellet to comprehend our ontology, data about the associated knowledge to patient entity is provided as Jess facts functions and SWRL rules are interpreted as Jess rules. The service, further, deduces from provided health guidelines and add the inductions to the Course of Action (COA) information base lastly control this through a user interface.

V. Ontology Model and System Architect

System architecture is planned by utilizing Protégé's highlights of characterization, consistency checking, and ontology testing. It goes about as an augmentation of the basic APIs, adding classes to speak to COA and predicting danger levels utilizing RDFS and OWL and RDFS and SWRL, respectively.

A. *Evaluation of the Implemented Approach*

We have created an ontology-based reasoning model to assist the patient in the given scenario. We have used ontology reuse approach (Caldarola, E. G., & Rinaldi) to utilize the existing COA model; however, in our model we also add different classes, object properties, data properties, and instantiation.

System architecture is designed by making the full use of Protégé's features of classification, consistency checking, and ontology testing. It acts as an extension of the underlying APIs adding classes to represent COA and danger levels using RDFS and OWL DL.

Consequently, we can support inferencing with SWRL rules using the Drool Engine. We have created and edited classes and their characteristics, accessed reasoning engines, executed queries and rules, added individuals and visualized relationships between concepts through a customizable graphical user interface.

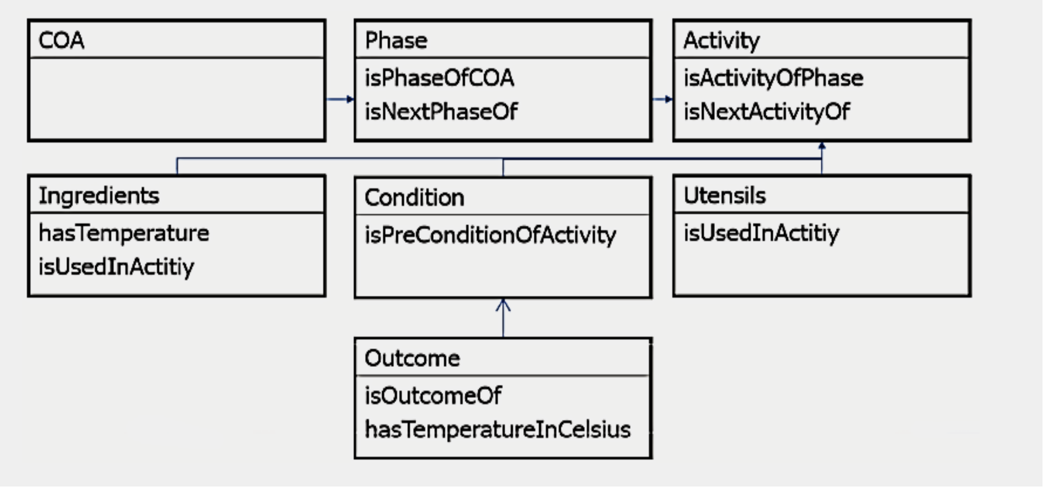

Fig. 1. COA model

OWL is chosen because it allows us to set property restrictions such as functional, inverse-functional, transitive, symmetric, asymmetric, reflexive, and I reflexive. These allow us to better capture relationships between objects.

RDF defines the relation between two concepts as a semantic triple based presentation, which allows structured and semi-structured data to be exposed, mixed, and shared across different applications, regardless of the difference between the underlying schemas.

SWRL is also used to write rules in the form of an implication between an antecedent and consequent. In SWRL, if the conditions in the antecedent hold, then the conditions in the consequent also holds.

The COA model is built from classes that represent the objects and users in the environment as more abstract concepts, such as danger level. To clarity, the instance of the constructed COA with attached guidelines, will be from now on referred to as objects in the domain ontological context. While objects can change the main features of the COA model, that are designed to be separate from the daily activity data to provide an application independent core model that can be reused to support other danger identification scenarios.

Our ontology is organized as a hierarchy of classes, that is, objects which classify individuals (instances) with relational properties represented as object properties and states classified as data properties.

The relational properties and states of the objects capture the relevant characteristics and describe the environment in terms of logical concepts.

The recommended Course of Action (COA) is sub-divided into three main categories: phase, activity, and condition. COA depicts a plan to undertake the activities of daily life successfully and it is further divided into phases. There are many sequences of activities that must be performed for the successful completion of a task. Individual tasks that are not part of a sequence are designated as activities. A condition is a state of being that is a prerequisite for a certain activity. For example, making a cup of tea has hot water as a condition.

According to our scenario, we add some classes and relationships as follow:

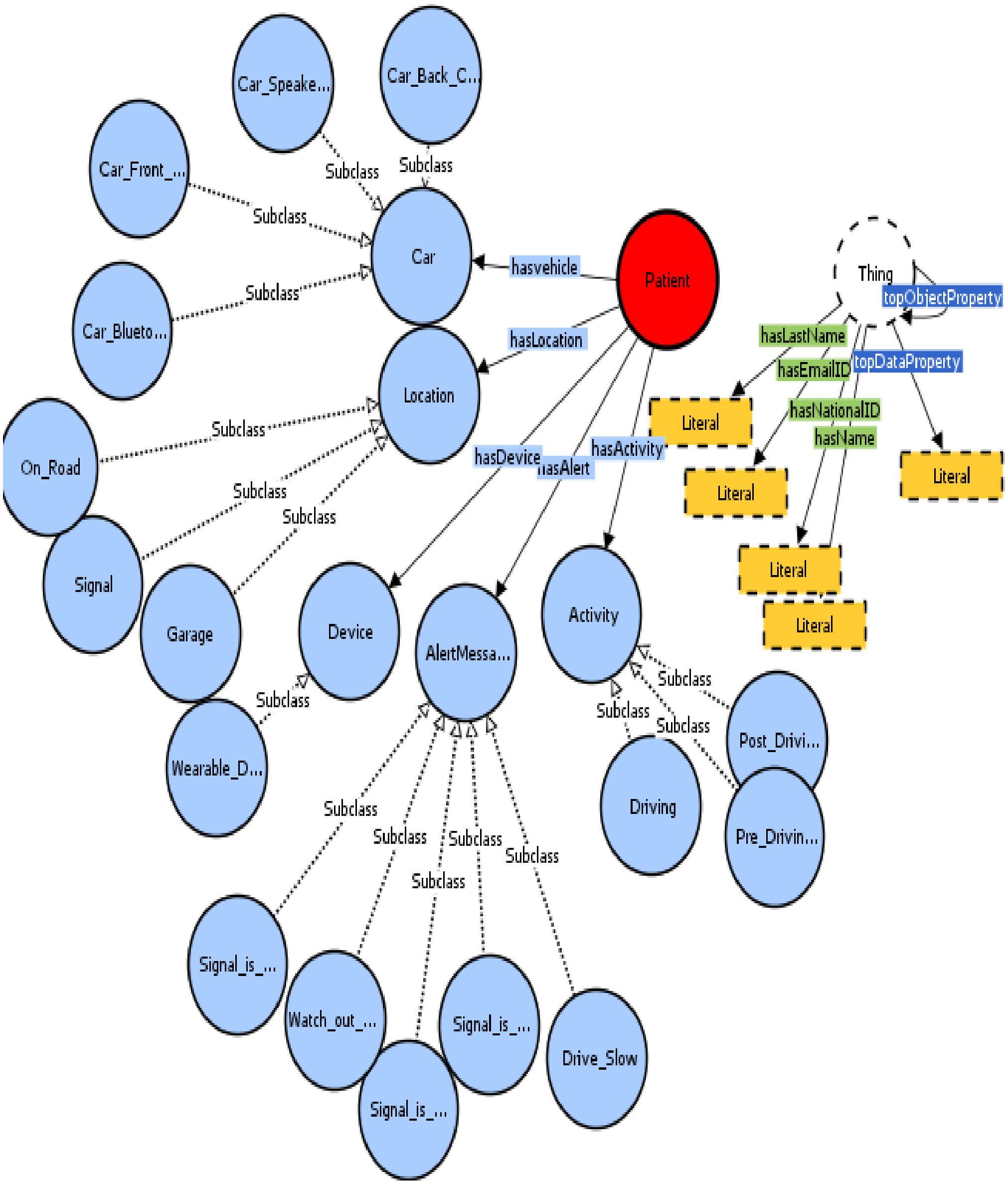

Fig. 2. Purposed concepts for the particular scenario

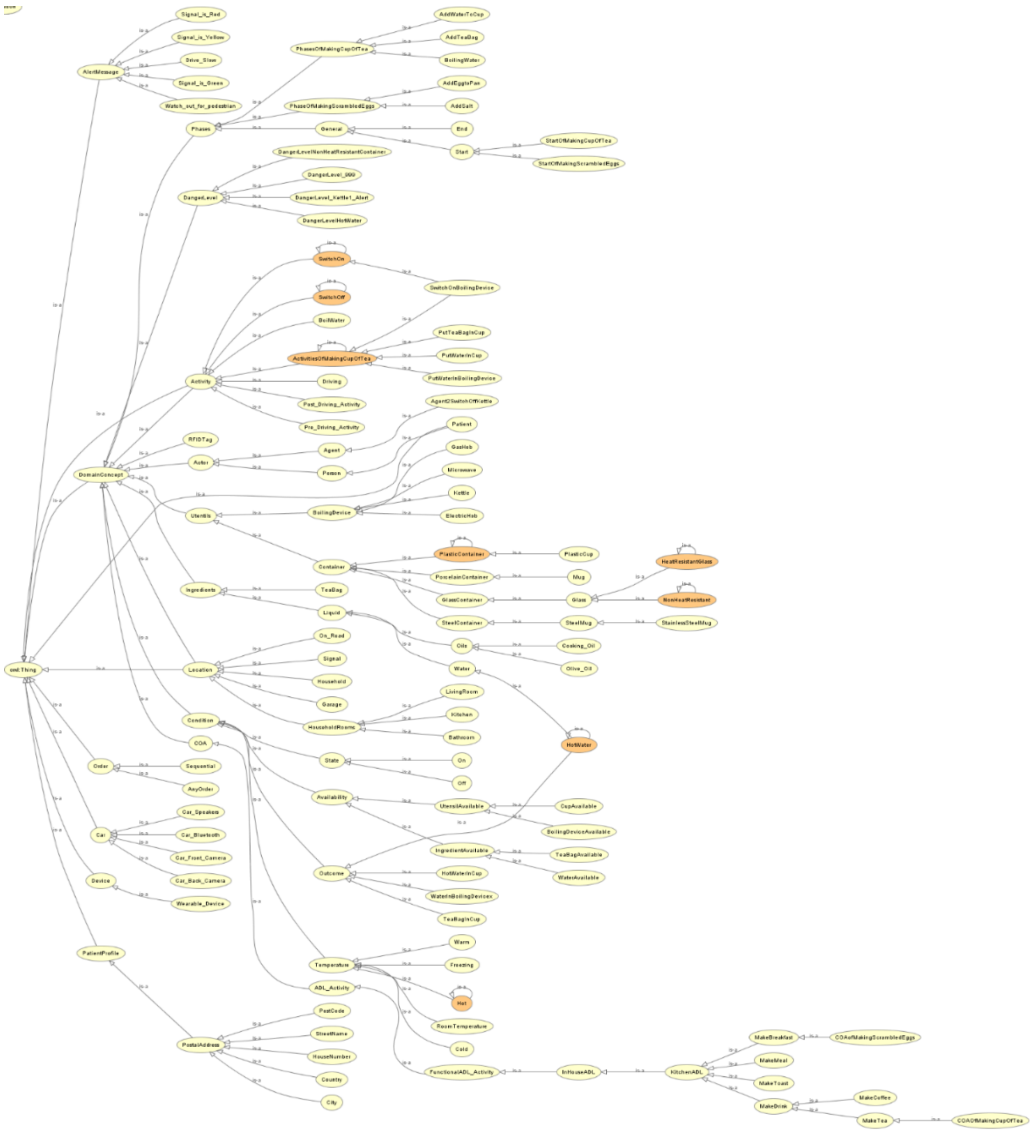

Fig. 3. Class hierarchy

Firstly, we create classes then define Object properties according to the scenario. Afterwards, we write SWRL rules to get the desired result. For example, the number of times a person has taken a shower can be taken as a hypothetical scenario. In this scenario, the person will have a sensor on the shower tap to alert them if they have used the shower or not. It will also alert them if the shower has not been used for more than 4 days to urge the user to take a shower.

VI. SWRL RULES (PELLET REASONER TO INFERENCE KNOWLEDGE)

```
hasAlert(?p, Signal_is_Red) -> hasAlert(?p, Stop_the_Car)
hasAlert(?p, Signal_is_Orange) -> hasAlert(?p, Start_the_Car_and_be_Ready) ^ hasAlert(?p, Watch_out_for_pedestrian
hasAlert(?p, Signal_is_Green) -> hasAlert(?p, Drive_now) ^ hasAlert(?p, Watch_out_for_pedestrian)
```

Fig. 4. SWRL

Following is the implementation of rules and we use pellet as a reasoner for inferencing.

Fig. 5. Asserted value by the sensor to the wearable device of the user that the signal is green

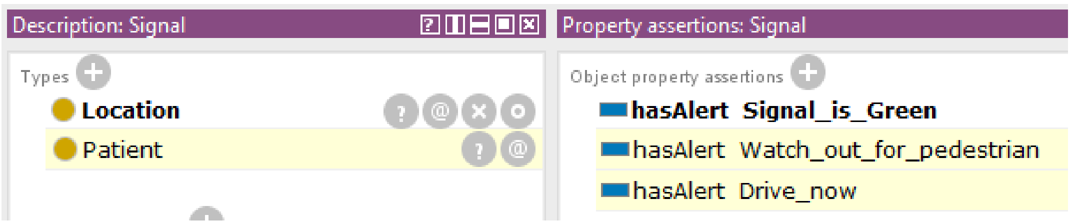

Fig. 6. Inferred value by the sensor to the wearable device to alert the user

Fig. 7. Asserted value by the sensor to the wearable device of the user that the signal is red

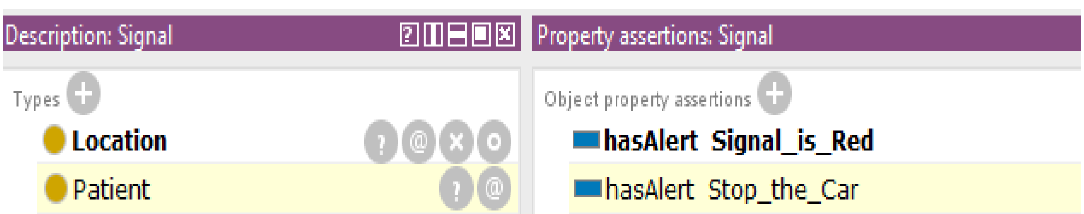

Fig. 8. Inferred value by the sensor to the wearable device to alert the user

Fig. 9. Asserted value by the sensor to the wearable device of the user that the signal is orange

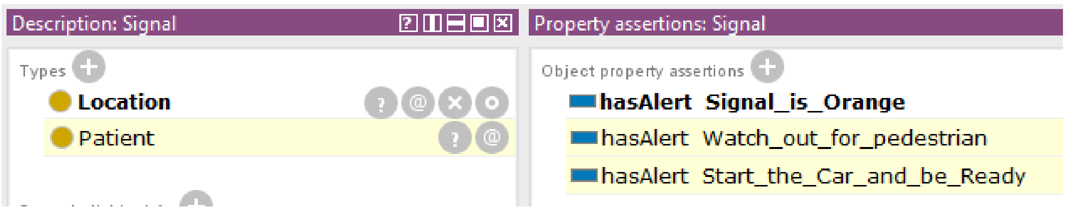

Fig. 10. Inferred value by the sensor to the wearable device to alert the user

We write SWRL in ROWL and use Pellet Reasoner to get the desired result.

The following figure displays our whole system.

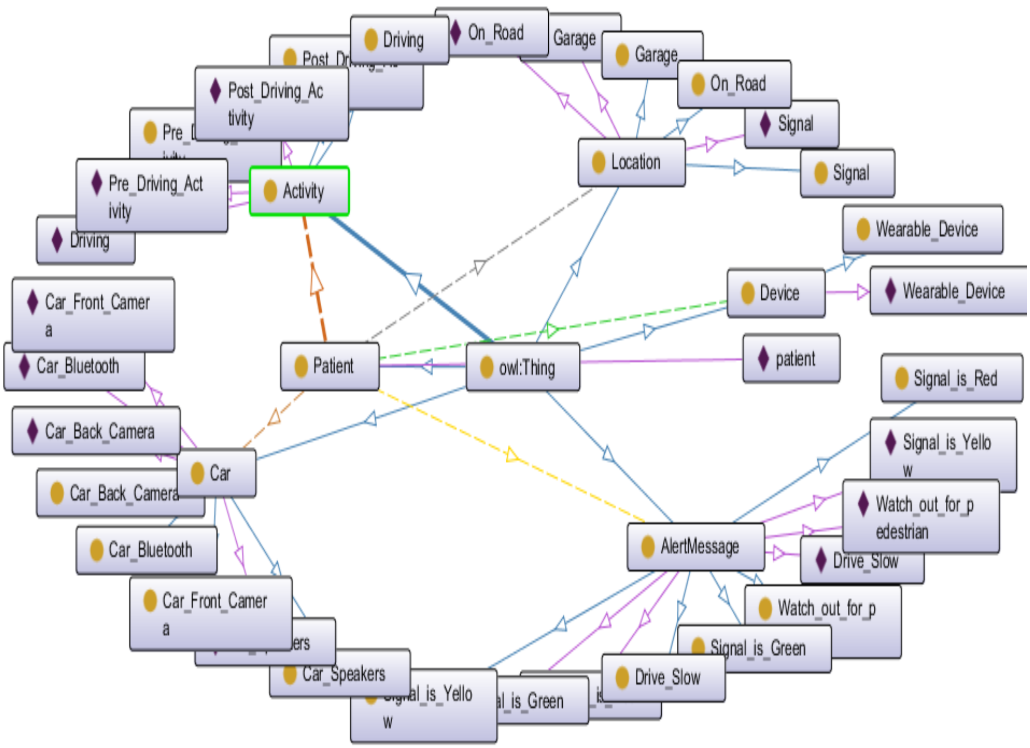

Fig. 11. Graph of relationships between purposed class and instances

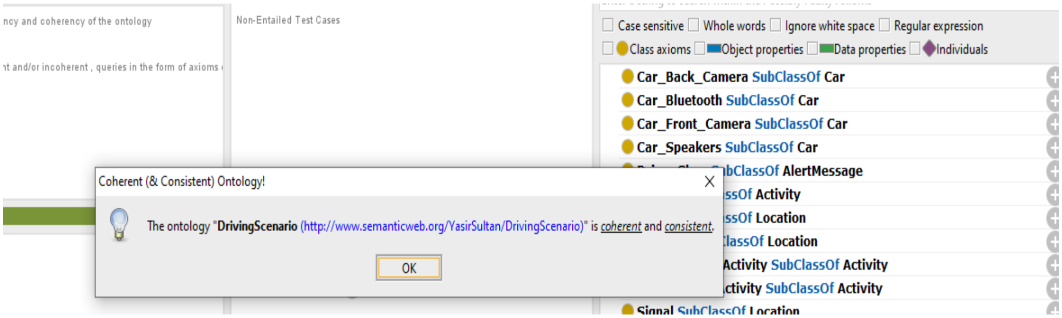

Fig. 12. Validation of Ontology by reasoner

The fig 12 displays the validation of the system by running the reasoner to check the consistency of our model.

VII. Conclusion and Future Work

This paper discusses a unique and a very high-end risk scenario in which an Alzheimer's patient is driving. We have taken this scenario because driving is an important part of an independent lifestyle; however, Alzheimer's patients struggle with this activity on a daily basis. Our aim is to assist Alzheimer's patients complete this activity in an uncomplicated/easier manner. The research proposed an ontology-based semantic model, where all activities of the patient are monitored, dangers are deduced, and a proper and safe course of action is suggested for the patient. In this model, we have used free source platforms and sensors that are more powerful and affordable for the patients. Though we have strived to determine major events that may occur in this scenario, more work should be done in this regard. Future studies should focus on the same thorough activity recognition. Future work should also be based on patients with mild Alzheimer. The extended research area is optimization of computerized services provided in a smart

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