Automating the Process of Traffic Orientation Through Mobile Devices and Ontologies

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AUTOMATING THE PROCESS OF TRAFFIC ORIENTATION THROUGH MOBILE DEVICES AND ONTOLOGIES

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Abstract: *Mobile devices are used in all activities undertaken by users and 90% of them have used at least once a mobile device to search for local information navigation and acted on the basis of data. In this material is presented the use of mobile applications for traffic navigation or assistance and how they can contribute to the automation of orientation in traffic through traffic signs. Traffic signs around the globe are very different, even if some countries ratified conventions or adopted common specifications. In addition to that, a part of traffic signs differ from country to country even if they have the same road signal convention. This paper work aims to establish a global knowledge base with traffic signs and traffic rules dictated by them. In this way when a driver travels in foreign countries by car he can be helped by the mobile device in order to recognize the traffic signs. The ontology design is made by using Protégé software together with an RDF/RDFS approach. It uses a class hierarchy with classes like RoadSign and TrafficRule in the top of it. SPAQRL is the query language used to clean the knowledge base. At the beginning it will be populated with traffic signs from Romania. Ontology will be the backend of the mobile application that provides recognition of traffic signs and assists drivers from around the world in traffic navigation. In order to motivate the users to be active in the community and add new signs in the application a gamification approach is used.*

Keywords: *Traffic Sign; Mobile Devices; Mobile Application; Ontologies; RDF; SPARQL; Protégé*

I. The Use Of Mobile Applications In Road Traffic

Nowadays, mobile devices have become tools used anywhere for anything. They are becoming more powerful and available to all users. They are also used in road traffic aiming to improve driving pleasure, by linking smart car driver and the outside world. The application allows faster assimilation of traffic information, while the driver keeps eyes on the road, no need to move constantly in sight of the distant foreground.

Each user of a smartphone has, on average, 17 applications installed, and 90% have used at least once a mobile device to search for local information navigation and acted on the basis of data. About two thirds of people who have a smartphone search, weekly, information on traffic, while a third seeks daily information. Observe thus tilting the need for assistive technology and traffic through mobile devices.

The problem has been addressed roadside assistance several companies that have developed solutions that help leaders come.

Waze social GPS Maps & Traffic [1] is a navigation application that addresses the holders of smart phones and it is used internationally. It is based maps generated by road users can report there are anomalies, allowing continuous optimization of routes leaders. The application sends automatically to all users updated information regarding fuel prices and problem areas and modify the route drivers to avoid them. For ease of use and ability to send new information even while driving, allows using voice commands instead of the usual menu. For

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interactivity, the solution was designed like a game, and users get points after the activities to edit the map, and then placed in an overall ranking of customers that changes monthly.

Similar applications can be made for recognition of traffic signs and if the application fails to identify a traffic sign, the user to specify what type of traffic sign is and thus receives points in a general ranking.

User taker certain meanings of the sign. The meanings based on the analysis of other similar traffic signs.

For each new sign identified verify the number of users that specify a sense and only after several users have the same sense of a sign they receive their items and points are saved in a centralized database.

Consider the set of DU, which is composed of *ndu* users where $DU = \{DU_1, DU_2, ..., DU_{ndu}\}$. It is considered the number $al < ndu$. *al* represents the number of users who need to confirm a meaning from the set SS composed of *nss* texts that are supposed to be the meaning of traffic sign, Figure 1.

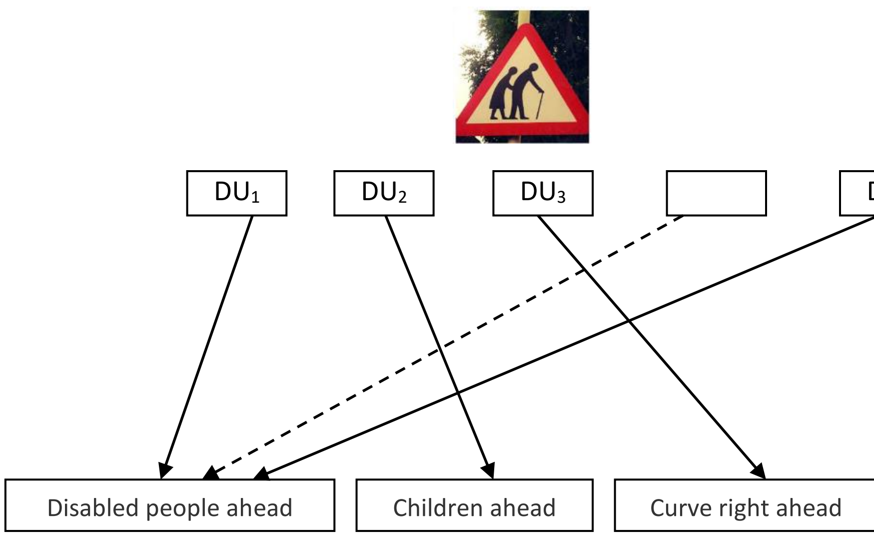

Figure 1. The vote for one traffic sign

The user can not select any item in the set SS, and to introduce himself a description of the sign. Description analyzed by ontologies and assigned to one of existing texts in the set SS or added a new text in it and the nss number will be increased by 1.

After confirmation of a text by al users, this text is considered representative of the traffic sign. Those of users who chose understand that receiving a number of other forum users *npr* points and chose another meaning not receive any points. In Figure 1 the users DU_1, DU_{ndu} and other users who voted the first option get *nrp* points. In this way it becomes a serious game application that will develop through users.

II. The Traffic Orientation Through The Traffic Signs

Traffic Sign Recognition - TSR [4], [5] has become nowadays a subject that has gained considerable interest, mainly due to increased demand for intelligent applications, including the autonomous driving and Advanced Driver Assistance Systems - ADAS.

TSR – Traffic Sign Recognition [3] involves connecting two concepts, each totaling a number of steps: TSD - Traffic Sign Detection in the coordinate system of the image, and TSC - Traffic Sign Classification. The first refers to accurately locate traffic signs in a picture, depending on the geometrical characteristics, while the second involves associating signs with the existing traffic code, for example by looking image into a set of template images, stored in a database.

Road signs were designed so that the man should be able to identify them in various conditions, in a manner as simple [2]. They are clear design principles in terms of shape, color, images and text used. But when it comes to using technology to perform this task, things seem to outline a pattern recognition problem (pattern recognition).

Traffic signs enjoy unique characteristics that make them easily identifiable from the multitude of objects in the open. These properties were pursued especially when we tried to develop mechanisms for the detection and recognition of road signs. Most paper [2], [3] proposes an approach in two phases, the first focuses on identifying areas of an image of interest, verifying the hypothesis of a road sign (called generic detection), and the second on determining the detected signal type (generically called recognition). Detecting the presence of possible signs mainly uses color information, followed by analysis of geometric edges or corners. A neural network has been designed to allow retrieval of the relevant characteristics of color and shape of a sign, which have been shown to have a significant precision, but involves a heavy volume of calculations.

A system for traffic sign recognition to be used to ensure continuous monitoring of the driver, the vehicle and the road, for example, to warn the driver about potentially hazardous situations that may occur in traffic. The main purpose of such an intelligent system focuses largely on increasing road safety and transport efficiency.

However, a robust automatic identification and real-time traffic signs can assist the driver, and by taking on some of the tasks, thereby significantly increasing safety and driving comfort. For example, it can remember that the current maximum accepted speed, alerting the driver when the road deviates from the regulations in force, or may perform certain maneuvers prevent inappropriate.

Road signs revolve around two main phases: detection and recognition. In the first step the image is pre-processed, improved segmented sign in accordance with the properties related to the color and shape. It follows a segmented image, which can identify the regions to be recognized as road signs. The efficiency and speed of detection are key factors in the whole process because they reduce the search space, indicating potential regions. In recognition stage, each of the candidates obtained in the previous step is tested on a set of features to decide whether part of a certain group of traffic signs or not, and based on these features will be integrated into a particular class, if fit is applicable. Characteristics are chosen in order to highlight the differences between classes and sign the form plays a crucial role here, in general signs may be included in such classes: triangles, circles, octagons, etc. Then comes the icon analysis to achieve the next stage of classification, where the study of shapes and text inside the sign, the individual can decide the class of which the sign in question.

III. Centralization Of Traffic Signs And Technologies Needed

Traffic signs around the globe are very different. If some countries ratified conventions like Vienna Convention on Road Signs and Signals [6, 7] (the case of European countries) or adopted The Manual on Uniform Traffic Control Devices (MUTCD) [8] (especially US influenced countries), many countries didn't. Even so, a part of traffic signs differ from country to country even if they have the same road signal convention. This thing makes that the same sign could look totally different from a country to another (Figure 2). Having in consideration that many countries apply the *Ignorantia juris non excusat* [9] principle, then it is the driver's duty to learn the traffic rules and traffic signs if he travels by car in a foreign country. Even the rules themselves are not part of this work paper, many of them are dictated by road signs and can be easily deducted. Automatic recognition of road signs and their applicable restrictions can be a very helpful tool for drivers around the world in general and for the proposed application's users in particular.

Figure 2. Unguarded railroad crossing sign in Romania (left), United States (middle) and Germany (right)

It is true that automotive companies already developed systems for traffic signs recognition and automated driver assistance systems called ADAS, but they are specific to the manufacturer and to the market where the cars will be sold. Thus, unfortunately there isn't a global database with country specific road signs or an initiative regarding this.

Having this fact in consideration, the current work paper aims not only to propose a new approach for a mobile sign recognition application, but also a way to construct an open source semantic knowledge base with traffic signs from around the world. This can help an AI approach for assisting the driver and, more important, any other third party application that want to use this kind of data.

Mobile devices have all the necessary sensors for data acquisition for an application like this: camera, GPS, text to speech and voice recognition support. Together with a gamification approach [11] we can assist the users to become better drivers and to avoid life threatening situations, and also to empathize with the community and recognize traffic signs that they know but the app don't. In exchange for some experience points or application gifts we get new signs in our knowledge base. A similar approach was used by Google when they bought the presented Waze app in order to have real time traffic information [12].

There are also other start-ups that want to use the mobile devices' sensors together with an external video camera to help the users drive well and Carvi it's one of them [10]. CarVi employs the vision based safety tools to gather data, using a small dashboard camera installed in the car that communicates with a smart phone. The camera captures video which CarVi analyzes in real time. If it senses potential trouble, it issues audible and visual warnings. The app monitors safe lane changes, front end collision danger, reckless driving and hard braking. Unfortunately the app doesn't use a traffic signs recognition system or anything similar.

Linked Data is about using the web to connect related data that wasn't previously linked, or using the web to lower the barriers to linking data currently linked using other methods [13]. More specifically, Wikipedia defines Linked Data as "a term used to describe a recommended best practice for exposing, sharing, and connecting pieces of data, information, and knowledge on the Semantic Web using URIs and RDF."

A Uniform Resource Identifier (URI) is a string of characters used to identify a name of a resource. Such identification enables interaction with representations of the resource over a network, typically the World Wide Web, using specific protocols. Schemes specifying a concrete syntax and associated protocols define each URI. The most common form of URI is the uniform resource locator (URL), frequently referred to informally as a web address. More rarely seen in usage is the uniform resource name (URN), which was designed to complement URLs by providing a mechanism for the identification of resources in particular namespaces.

The Resource Description Framework (RDF) is a family of World Wide Web Consortium (W3C) specifications originally designed as a metadata data model. It has come to be used as a general method for conceptual description or modeling of information that is implemented in web resources, using a variety of syntax notations and data serialization formats [14]. It is also used in knowledge management applications.

RDFS (Resource Description Framework Schema) is a set of classes with certain properties using the RDF extensible knowledge representation data model, providing basic elements for the description of ontologies, otherwise called RDF vocabularies, intended to structure RDF resources [15]. These resources can be saved in a triplestore to reach them with the query language SPARQL.

SPARQL (a recursive acronym for SPARQL Protocol and RDF Query Language) is an RDF query language, that is, a semantic query language for databases, able to retrieve and manipulate data stored in Resource Description Framework format. It was made a standard by the RDF Data Access Working Group (DAWG) of the World Wide Web Consortium, and is recognized as one of the key technologies of the semantic web [16].

Protégé is a free, open-source ontology editor and framework for building intelligent systems. It is supported by a strong community of academic, government, and corporate users, who use Protégé to build knowledge-based solutions in areas as diverse as biomedicine, e-commerce, and organizational modeling [17].

IV. The design and usage of the traffic signs ontology

1. The design

According to [6] the road signs can be divided in 7 major categories: A - Danger warning signs, B - Priority signs, C - Prohibitory or restrictive signs, D - Mandatory signs, F - Information, facilities, or service signs, G - Direction, position, or indication sign, H - Additional panels. The designed ontology will focus just on the first four categories (A - D) because they are the ones that can have a serious impact on the driver's and road participants' safety.

The first step in the design of the ontology is identifying the needed classes. They are available in the class diagram presented in Figure 3 which was exported from Protégé's OntoGraf representation.

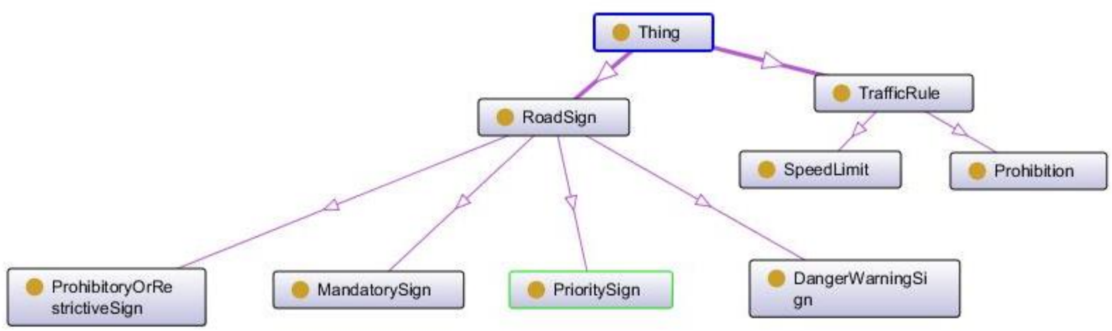

Figure 3 – Road Sign Ontology Class diagram

Next step is the identification of ontology specific object properties. For our case we will have properties like *enforcesTrafficRule* and *uneforcesTrafficRule*. Each property will be marked as transitive, asymmetric and inverse to the other one. Also they have restrictions like the acceptance of individuals of type *RoadSign* or *TrafficRule* as domain and only individuals of type *TrafficRule* as range. We will have also data properties like image, description and label, properties that will be applicable to the identified objects.

The only thing remained is the creation of individuals for every class. These individuals will be country specific and they will use the *rdf:langString* property in order to identify the country in which the sign or the traffic rule is used.

Our ontology will be populated at the beginning only with traffic signs and traffic rules from Romania. Every time the app identifies a known traffic sign it will warn the driver regarding the traffic rule that he can break (for example if the user drives over the speed limit or drives too fast in the proximity of a pedestrian crossing). If the app fails to identify the sign, then the user receives a push notification that will ask identify later the correspondent category for the sign (according to the ones that exist in the ontology) and select all the applicable traffic rules.

Through gamification techniques the users will be encouraged to add new signs in order to receive gifts. If the number of users that put a sign in a certain category will be over an aprioristic know threshold then it will be considered correct and added in the knowledge base. In Figure 4 we can see the created ontology with some identified individuals.

Figure 4. The created ontology with some individuals

2. The usage

The created ontology will be available to our app and to other third party apps through a SPARQL endpoint. This endpoint will receive requests that contain SPARQL queries and will respond with plain text or RDF triples. Let's say for example that we had identified a pedestrian crossing sign and we want to know what the driver should do. We will write the following SPARQL query:

```
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX roadsign:  <http://www.acs.ase.ro/RoadSignsOntology#>
SELECT ?trafficRule
WHERE
{
        roadsign:PedestrianCrossing roadsign:enforcesTrafficRule ?trafficRule
}
```

The result will be the individual Below30Kmph so we will know that we should warn the driver if he travels above this speed limit. In a similar way we will treat all the other SPARQL queries with the observation that ontologies are based on Description Logic so if it isn't a constraint that says otherwise everything is considered to be possible.

V. Conclusions

This work paper proposed a new approach in developing a worldwide traffic signs knowledge base by the use of mobile applications. With the help of image recognition techniques, gamification, semantic technologies and the last but not the least, user communities we can develop this kind of knowledge base. The ontology can be used by third party app through a SPARQL API and will be also part of the LOD cloud. In this way we can fulfil two major problems of our days, assisting the users in the process of driving and building a semantic versions of a worldwide traffic sign database.

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