SERVICE RECOMMENDATION SYSTEM FOR A SMART CITY

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Abstract

Smart Cities are complex spaces with a variety of information and points of interest, in which citizens can have access, whether visitors or residents. This paper presents a system of recommendation of points of interest in smart cities, aiming to improve the result of the search performed by the user. For this, an ontological model was used, through a case study, adding data from a city. Through this study, it is possible to demonstrate the potential of an ontological modeling to provide recommendations. These improve semantics and create standardization to facilitate knowledge sharing. The approach developed aims to recommend information from sights and health services. To test the system, SWRL rules were developed and, from them, inferences are made by a reasoner.

Keywords: recommendation of services, points of interest, ontological models, smart cities.

1. Introduction

According to data from the 2015 study conducted by the National Household Sample Survey (NHSS), 84.72% of the Brazilian population lives in urban areas and 15.28% in rural areas according to the Brazilian Institute of Geography and Statistics (IBGE, 2017). The IBGE estimates that by 2030, six out of 10 people around the world will live in cities, and by 2050, two-thirds of the world's population will live in cities (IBGE, 2017). This movement of people has as one of the main reasons the rural exodus, which is the migration of individuals from the rural area to urban areas caused by the economic factor of disruption of family agriculture. (VANDERLINDE, 2008)

A Smart City is one that uses information and communication technologies (ICTs) to promote improvements in the quality of life of its citizens at an affordable cost, optimizing the sustainable use of available natural resources. In this context, technology should be understood not as an end, but as a means of including citizens, either as co-creators or as maintainers, in the mechanisms that project improvements in the quality of life of the community (PÉREZ-MARTÍNEZ, et al., 2013). For Gallo many times, city managers are unaware of people's demands, either due to the excess and disorganization of information or failures in investment planning, which could be solved with a system that would help citizens and managers in the search for their solutions (GALLO, 2016).

The expression smart city, or smart city, came up in the 1990s with policies being created to guide urban planning (DEPINÉ, 2016). In the 21st century, technology companies began to use this term in software for services and organization of cities (DEPINÉ, 2016). Zanella et al propose that a smart city seek, using public resources, to optimize the administration and quality of the provision of services to citizens (ZANELLA, et al., 2014). Washburn & Sindhu highlight that smart cities use resources and computer systems to plan and inform services that the city offers, in an intelligent, interconnected and efficient way (WASHBURN & SINDHU, 2010). One way to model the structure of these systems is by using computational ontologies, in other words, having shared entities and relationships as a way to structure knowledge in solving a problem (GUARINO, et al., 2018).

In view of the above, this study has as main objective to develop an approach that involves a system of recommendation of points of interest for intelligent cities, based on an ontology, having as example the city of Cotiporã, located in the state of Rio Grande do Sul, Brazil, which has agriculture as the center of its economy (PREFEITURA MUNICIPAL DE COTIPORÃ, s.d.). The difficulty of selecting interests and organizing information or services with relevance among resident citizens and visitors to the city and administrative management, in the search for service to public services, may be factors to be considered with regard to increasing sustainability, education and knowledge for problem solving. The system that aims at this study, aims to filter, disseminate and recommend information of sights and services made available by health.

It seeks to validate the recommendation system through a case study involving the city of Cotiporã. Validation involves popular ontology with instances from the city of Cotiporã and, with this, the demonstration of how the recommendations occur.

This article is structured as follows: section 2 shows the related works; section 3 sets out the methodology; section 4 presents the case study of the system for the city of Cotiporã and in section 5 presents the conclusion.

1 Related Jobs

Sansonetti proposes a points of interest system (POIs), through a custom recommender located near the user's current position, that makes use of the level of detail algorithmic technique (LOD). (SANSONETTI, 2019). The study explores information about the user's social graph by giving more relevance to the POIs visited by their friends in the recommendation process.

As for the ontological recommendation related to tourism, Doycheva et al describe a personal tour guide, capable of generating cultural routes, which can be virtual or real, depending on the preferences or location of the user (DOYCHEVA, et al., 2020). The architecture of the guide consists of several intelligent agents that work with ontological networks and environmental network as a knowledge base, to generate tourist itineraries. Ontologies present the cultural and historical objects of Bulgaria, pattern and environment present the physical properties (place, working hours, and others) of these objects. In addition, dynamic route generation is demonstrated by the approach through an environment-oriented model.

Smirnov et al presents a system known as tourism assistant infomobility system (TAIS) to support tourists in a region and analyzes the actions of the user to reveal their preferences, in addition to recommending cultural heritage and objects based on information from the region (SMIRNOV, et al., 2017). TAIS offers intelligent services that support semantic data exchange using ontologies and the physical space in which the tourist is located is created as a cultural space. By the service of recommendation and implementation of a collaborative filtering technique, the cultural heritage objects provided to tourists are listed and tourists in unknown location can be assisted by mobile guides of the city who operate mobile devices.

To capture the impact of time on successive POI recommendation, Zhao et al's article proposes a space-time latent classification method (STELLAR) to explicitly model interactions between user, POI and time (ZHAO, et al., 2016).

Palumbo et al suggests a path with the use of a Recurrent Neural network to predict the next poi category in each POI (PALUMBO, et al., 2017). The location based social networking(LBSN) allow users to check in to a POI and share their activities with friends, providing publicly available data about their behavior. One of the distinctive characteristics of LBSN data in relation to traditional location prediction systems, based primarily on GPS data and focus on physical mobility, is the rich categorization of POIs into consistent taxonomies, which attribute explicit semantics with meaning to users' activities.

Hasegawa et al in the article "My City Forecast": develops an urban planning communication tool, to plan the city for citizens (HASEGAWA, et al., 2019). To provide the public with information related to the future of their cities and collect opinions based on the proposed system requirements. This tool integrates individual building demand forecasting models, people distribution, facilities, and administrative costs using different types of Open Data (OD).

Spoladore et al developed RoomFort, a cloud-based architecture that measurements illuminance, CO_2 concentration, temperature and humidity rate within the hotel room (SPOLADORE, et al., 2018). The system, designed to customize comfort metrics for business travelers, was developed using semantic web standards and reasons for data stored in a private cloud repository. It was postulated that, for greater accuracy of comfort metrics and their measurements, an ontology should be integrated into the hybrid recommendation algorithm. The recommendation system based on combination with ontology predicts the degree of user interest for (POIs) considering user preferences and POIs resources.

Palacios et al states that technology in general, CRM and social networks in particular have been identified as important facilitators in tourism and presents the POST-VIA 360, a platform dedicated to supporting the entire life cycle of tourism loyalty after the first visit (PALACIOS, et al., 2017). The system is designed to collect data from the initial visit through generalized approaches. After the data is analyzed, the POST-VIA 360 produces data accuracy after the visit and, once returned, can offer relevant recommendations based on positioning and bio-inspired recommendation systems. To validate the system, a case study comparing recommendations of THE POST-VIA 360 and a group of experts was conducted. Results show that the accuracy of the system's recommendations is remarkable compared to previous efforts in the area. The semantic model includes several entities (user, profile, visit, evaluation, concept, POI, similarity, content, promotion), as well as a set of relationships.

Palacios et al point out that the use of semantic infrastructures allows you to query information using SPARQL queries through a specific interface designed for the system that receives the necessary information and is responsible for generating the appropriate SPARQL query to access the semantic model (PALACIOS, et al., 2017). Regarding storage, they adopted the Jena API as the main framework for loading the ontology model and storing the data.

The domain of tourism, using the functionality of the POI and accessibility levels to provide personalized tourism recommendations, the study by Santos et al mentions that there are many recommendations regarding information systems, although for different purposes (SANTOS, et al., 2019). The article addresses a different perspective on recommendation systems, because it includes limitations and differences determined by everyone, physical or psychological and restrictions on access to tourist sites. The general proposal of recommendation described by Santos et al. considers various sources of knowledge and filtering techniques to enrich the quality of the results produced. The recommendation process begins with generating local recommendations, stereotypes, emotions, tags and society items (SANTOS, et al., 2019).

Santana et al presents an ontological model with the purpose of modeling elements of a city, in addition to recommendations appropriate to a person's profile, interests and intentions (SANTANA, et al., 2018). For this, the authors elaborated semantic rules of possible application to the model, seeking to demonstrate the projection of personalized recommendations from different variables related to the user and the context in which it is situated. The recommendations made from inferences about ontology showed great potential to use the specific needs of each user, who can be resident or visitor. The proposal based on ontology, is then variable to be expanded in order to increase its scope, covering aspects that may be relevant for a better adaptive recommendation. From the relational view presented among the classes of ontology, it was observed that a person has an interest in certain subjects, which are attended by different points of interest of a city. Inference rules were established to be carried out using the Pellet as an inference engine, considering that the model was proposed to assist in the adaptive recommendation of points of interest in favor of the interests and needs of its users (SANTANA, et al., 2018).

2 Recommendation of Points of Interest for Smart Cities

The proposal developed uses responsive interfaces that adapt to the various existing devices Smartphones, Tablets, Notebooks, Desktops that use diversified operating systems for their proper operation. The responsive interface is a technology that adapts to the screen size of the device for better visualization and navigability. França suggests that we use responsiveness in web system projects to achieve the greatest diversity of devices, making them increasingly flexible and accessible (FRANÇA, 2015).

When accessing the proposed system interface, the user informs if he is a visitor or resident of the city, his age, what he is looking for in Cotiporã (e.g. tourism, health). Based on the user's information, the system will return the interests of the search performed. If it is tourism, for example, it will return the places available for visitation and services offered, close to the person's location. This recommendation will be adapted to the tastes previously informed that the visitor or resident sought. Localization is the basis for the recommendation and the point of interest to be flexible and adaptable as the user wants.

The knowledge base used by the approach is structured in an ontological model adapted to the context of the city of Cotiporã. This knowledge base is composed of a database that is fed with data collected from the user's environment and the municipality of Cotiporã. To generate the recommendations, we used an engine of logical inferences and descriptive rules linked to the modeling adapted for the study of this city. This knowledge base has as output a set of user-recommended POIs.

2.1 System Features

The system features are described below:

a) The device connected to mobile web or wi-fi accesses the user's location data made available by GPS, if the system fails, prompts the user for latitude and longitude manually.

b) The citizen accesses the site of the municipality of Cotiporã, on the site finds a menu Smart Cities available, creating a brief registration, with name, email and password he logs into the system or if he already has the registration enters only user and password connecting the database and presents the interface of the preference filter.

c) After logging in, go to the interface where you inform if you are a visitor or resident of the city, your age and your point of interest.

d) By clicking search the system makes the inferences from the logical rules to which it returns the recommendations of the POIs near its location, according to the pre-registered ontological knowledge base with information from the city.

e) The system should list recommendations as nearby sights or services offered by the health area based on your location.

f) The system should not be invasive and allow the citizen to filter in the interface only relevant points of interest.

2.2 Methodology Used

The methodology guides the construction and/or reuse of a consistent ontological model in the construction of a system. McGuinness & Noy with "Ontology development 101", exposes that technology changes frequently, so systems require constant updating in their models, POIs, services, security requirements, among others (McGUINNESS & NOY, 2001). This methodology is divided into seven steps of development:

Step 1. Determine the domain and scope of ontology. McGuinness & Noy suggest some issues that help define the domain or scope of ontology (McGUINNESS & NOY, 2001):

What is the domain that ontology will cover? Ontology will cover the domain and/or scope of smart cities.

What are we going to use ontology for? We will use ontology to recommend points of interest and/or services that the city offers.

What types of questions should information in ontology provide answers to? The ontology should answer the questions whether the user of the system is a visitor or resident of the city; what is your age; what you are looking for in Cotiporã.

Who will use and maintain ontology? Ontology will be used by visitors or residents and the system administrator. It will be maintained and updated by the author of this project.

Step 2. Consider the reuse of existing ontologies: With the possibility of importing and exporting ontologies by publishers, it allows the editing, reuse and sharing of existing models in other computational contexts. The interaction with other systems through languages that interpret and make available semantic information enriches the existing knowledge base and allows reuse in other pre-existing bases, such as the case study conducted for the city of Cotiporã that uses the pre-existing ontological base modeled for the city of Gramado, used in this work.

Step 3. Enumerate important terms in ontology: In the designer of an ontology it is productive to describe terms to present to a user, without initially worrying about the overlap of these terms and their properties. Based on the following questions: What are the terms we would like to talk about? In the resolution of this question I present some relevant terms found in ontology such as people, points of interest, city, location, among others presented in this study. What properties do these terms have? The properties can be a person's age, their name, their time, among others. What would we like to say about these terms? The questions of refinement of the terms can happen after we have a sketchy modeling.

Step 4. Define classes and class hierarchy: Given several approaches available for class definition, you can adapt to which one best fits the modeling being developed: top-down, ascending, or a combination of the two already mentioned. In this modeling we define the most salient concepts first and then generalize, specifying each class better. For example, we create the person class after the visiting and/or resident subclasses.

Step 5. Define the properties of classes – slots: After performing the previous steps and with the classes already defined, we characterize the properties, according to the ontology reused in this proposal the person class, has age and has name. This person class is related to the hierarchy of visitor, resident, and administrator subclasses, to which these classes derived from the person class inherit the properties of the person class.

Step 6. Define the facets of slots: The definition of facets for a slot is the type of data to be added, for example the person/visitor class has "has a name" and the "person's name" is a string (word or a string, phrases, texts) or the person/visitor class "has age" characterized as a number (with cardinality) that defines how many numbers can count in that age field space. The most common being as: string, number, Boolean value (true or false), enumerated or instances that allows relationship between individuals.

Step 7. Create instances: Final step in ontological modeling is first before a class, create an individual instance within that class, and populate with the values appropriate to the slots. For example, within the POIs class, instances were created with the sights of the city of Cotiporã, where each tourist spot will have relationships and slots that will be specific characteristics such as location name, latitude and longitude, among other information.

It is important to emphasize that there is not only one way to develop or improve an ontology in the modeling of a system, there are several, and it is up to the author to decide the best approach to solving the problem. Figure 1 shows the ontological structure developed by (SANTANA, et al., 2018) and reused as indicated in step 2 of this methodology.

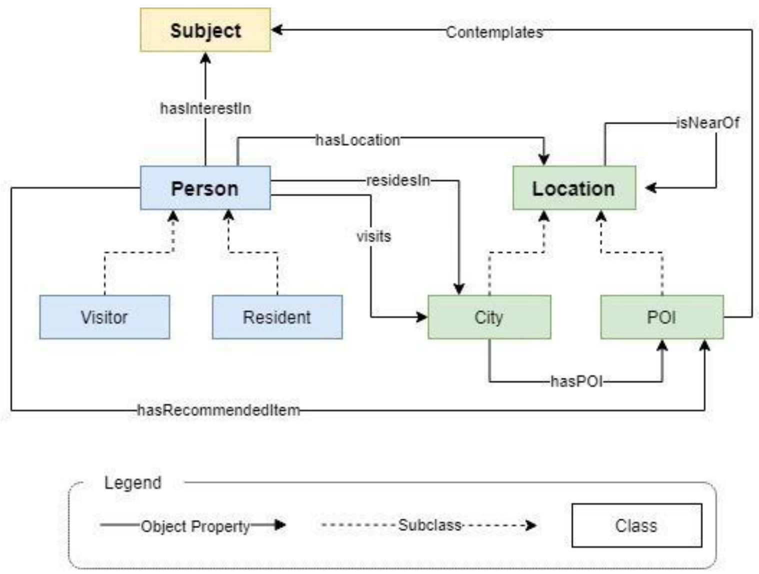

Figure 1. Ontology Classes and their main relationships

Figure 1 shows the reused initial classes of the (SANTANA, et al., 2018) and the interconnections between classes. The Subject class contains the areas of interest of a city, e.g. tourism, health services. The Person class contains the visiting and resident subclasses. The City class contains the cities added in the modeling. The POI class contains, for example, sights, points of health services. The location class contains the latitude and longitudes of the POIs. The system is based on the location of the person who is obtained through the Google Maps API and is compared with the location of the NEAROf POIs (close to) 100 meters, if the API returns that the POI is 100 meters from the person, then the nearOf property (near) is true and fits the rule that generates the recommendation.

As we can observe Figure 1 presents the relationships between the classes. A Person when accessing the system, informs if you are a visitor or resident and what is your interest, whether it is tourism or health. Through this data the system relates to the class at the time of inference of the rule to at the end generate the recommendation. Therefore, the path traveled within the ontological model is related to the following way: Person is visitor, for example, hasInterestIn (has an interest in) subject (tourism or health), the system analyzes whether the person is residentIn (resides in) city (Cotiporã), analyzes the current location of the Person and if the city hasPOI (has points of interest) and which POIs are nearOf (near) Location, at the end relates to the result hasRecommendedItem (has item recommendation) that with templates (contemplates) the POIs found in ontology.

3 Case Study: Cotiporã

There are several definitions for case studies as described in (WOHLIN, et al., 2012) the experimental method is the most focused on the investigation of coexisting cases in a given context. (DRESCH, et al., 2015) reports that case studies are valuable because they allow detailing the investigation and understanding of the problem with greater depth based on diverse data sources. For the effectiveness of the case study, the possibilities of use are exposed, where a case demonstration on recommendations made is reported, based on the user's location and the possibilities of results. In the following organization, it was reported about the reasoners that are the inference mechanisms used in the proposal and to finalize two scenarios of application of SWRL rules that generates the filters of the recommendation, scenario 1 tourism and scenario 2 health.

3.1 Possibility of Use

We present the possibilities of use in the steps described in Figure 2: The user looking for recommendations of interests and services of a city, accesses one of the available devices, connects to a web browser and searches the city's website, when opening the site, clicks on the menu available smart cities, logging into the system. The interface connects to the server where the city database is stored, communicating the device and searching for its location through the data found. On the server finds the ontology and logical rules that filter user preferences, returning the filter as a response to the device interface.

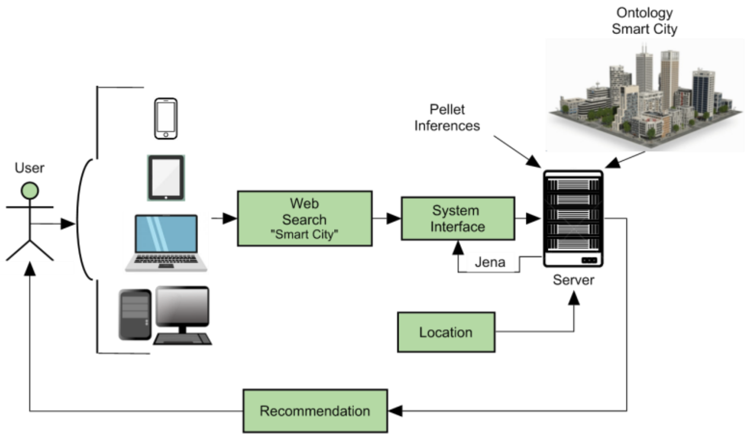

Figure 2. Architecture of the proposal

The recommendation helps by reducing the search time for the sights or services made available by health, among other possibilities of future areas that may be added to the proposal.

3.2 Inferences on Rules for Recommendation

A reasoner is a semantic reasoner, capable of deducing and inferring logical sequences and returning a possibly accurate result. In this proposal, through a set of SWRL logical rules they filter and return a recommendation based on the user's location. Reasoners or inference engines enable the search for knowledge necessary to solve a problem. Inferences provide decision-making from axiomas that are logical translated into true expressions. Among the inference engines used for inference logic and semantic web, we present some: ELK Reasoner, FaCT ++ Reasoner, Hermit Reasoner, Ontop Reasoner and Apache Jena, Pellet, these inference engines can be called Semantic Reasoner. In this project we used the Pellet inference engine through the *Protégé tool,*because it contains a complete set of characteristics, is open source, has greater expressiveness of descriptive logic combining with two native profiles, total incremental classification, support for SWRL rules and justified with compatibility with the three APIs verified in a former project.

W3C recommends the SWRL rules language because it has greater use and relevance on the web. It is based on the OWL language, using its set of axioms to construct the rules (HORROCKS, et al., 2004). The creation of the rules is divided into two steps: the first that is the construction of the SWRL logical rules and the second step is the inference of this rule if its expression is true. Inference aggregates the database with the result of the rule that is the recommendation of the city-related point of interest. SWRL rules are the basis for aggregating interoperability to semantic web systems (O'CONNOR, et al., 2005). The rules are composed of antecedent (body) -> consequent (head) as presented by the (MIGUEZ, 2017). Next, two rules presented in figures 3 and 4 were tested, whose conditions allow specific recommendations to be made in the identification of classifications.

1. Scenario 1: Tourism

Maria is a visitor from the city of Cotiporã who is interested in getting to know the sights. During a city tour, Maria accesses the Cotiporã website and finds the smart city menu. When registering in the system enters your name, age, and tourism interest. By clicking search, the system internally infers a rule that returns the result of the recommendation to Maria with the name of all the sights registered in the ontology. Based 100 meters from your current location point.

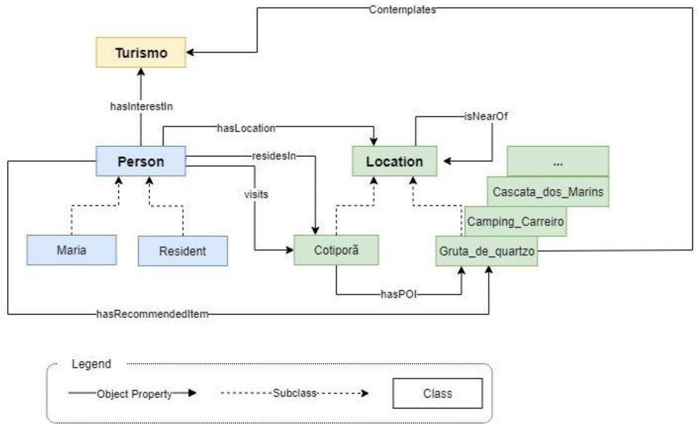

Figure 3. Model applied in Tourism

In Figure 3 we can perceive the path taken by inferring a rule in the model, where Mary is a person who hasInterestIn turism, she is located in Cotiporã and 100 meters from her current location point the system recommends several points of interest that contemplates the subject of tourism. Figure 4 follows a test applied to filter tourism-related points of interest, where the latitude and longitude location of these POIs are already added within the ontological modeling of the city of Cotiporã. The rule is described as follows:

Subject(?s) ^
contemplates(?poi, ?s) ^
POI(?poi) ^ Person(?p) ^
hasInterestIn(?p, ?s) -> **hasRecommendedItem(?p, ?poi)**

Through this presented rule it is possible to analyze the example of logic executed through the reasoner. The individual instantiated in ?s has a subject (turism), and ?poi and ?s contemplates (?gruta_de_quartzo, ?turism), then ?poi is POI (gruta_de_quartzo) and ?p is Person (Maria) that hasInterestIn (Maria, turism), generating the hasRecommendedItem for Maria the gruta de quartzo. This rule that runs generates the list of recommended items presented in Figure 4.

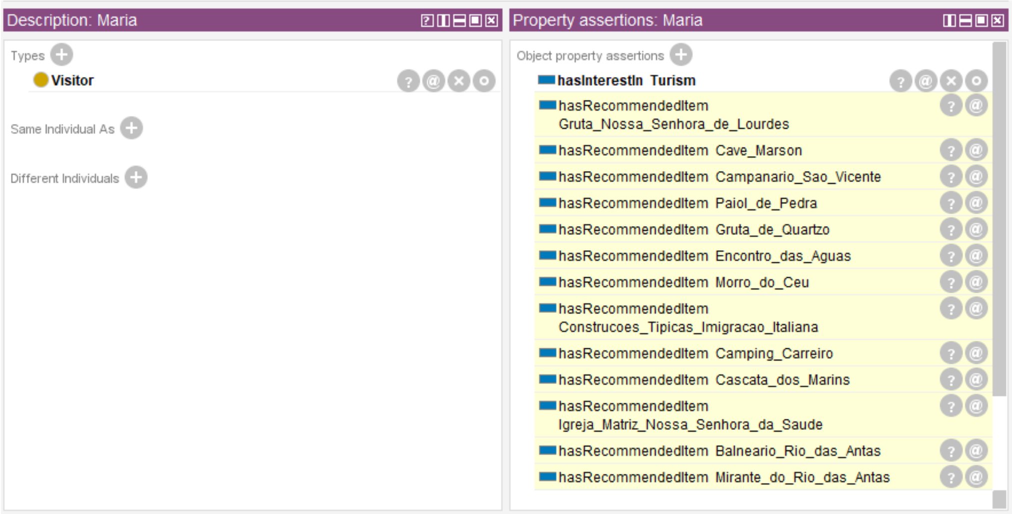

Figure 4. Inferred Rule of POIs for Tourism

The visitor who is interested in tourism and receives the following recommended items: gruta_nossa_senhora_de_lourdes, cave_marson, campanario_são_vicente, paiol_de_pedra, gruta_de_quartzo, encontro_das_aguas, morro_do_ceu, construcoes_tipicas_imigracao_italiana, camping_carreiro_cascata_dos_marins,igreja_matriz_nossa_senhora_da_saude, balneario_rio_antas, mirante_do_rio_das_antas.

2. Scenario 2: Health

Paula is a visitor from the city of Cotiporã who is interested in getting to know the health services. During a city tour, Paula accesses the Cotiporã website and finds the smart city menu. When registering in the system enter your name, age, and interest health services. By clicking search, the system internally infers a rule that returns the result of the recommendation to Maria with the name of all health services registered in ontology. Based 100 meters from your current location point.

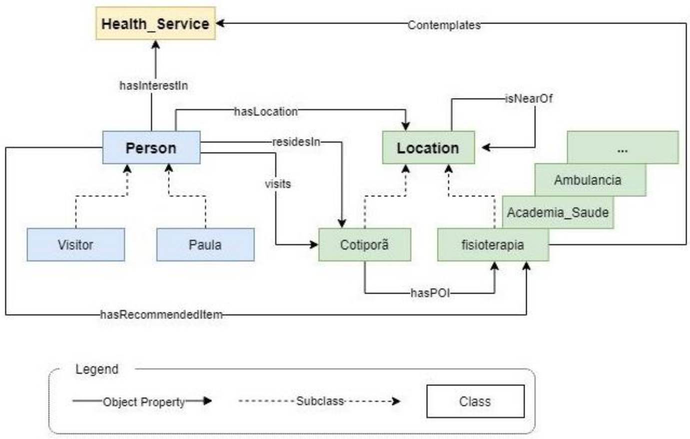

Figure 5. Health model applied

In Figure 5 we can perceive the path taken by inferring a rule in the model, where Paula is a person who hasInterestIn health services, she is located in Cotiporã and 100 meters from her current location point the system recommends several points of interest that contemplates the subject health services. Figure 6 follows a rule for filtering out services made available in healthcare.

Subject(?s) ^
contemplates(?poi, ?s) ^
POI(?poi) ^ Person(?p) ^
hasInterestIn(?p, ?s) -> **hasRecommendedItem(?p, ?poi)**

The individual instantiated in ?s has a subject (serviços_saude), and ?poi and ?s contemplates (?physiotherapy, ? serviços_saude), so ?poi is POI (physiotherapy) and ?p is Person (Paula)who hasInterestIn (Paula, serviços_saude), generating the hasRecommendedItem for Paula the physiotherapy service. This rule that runs generates the list of recommended items shown in Figure 6.

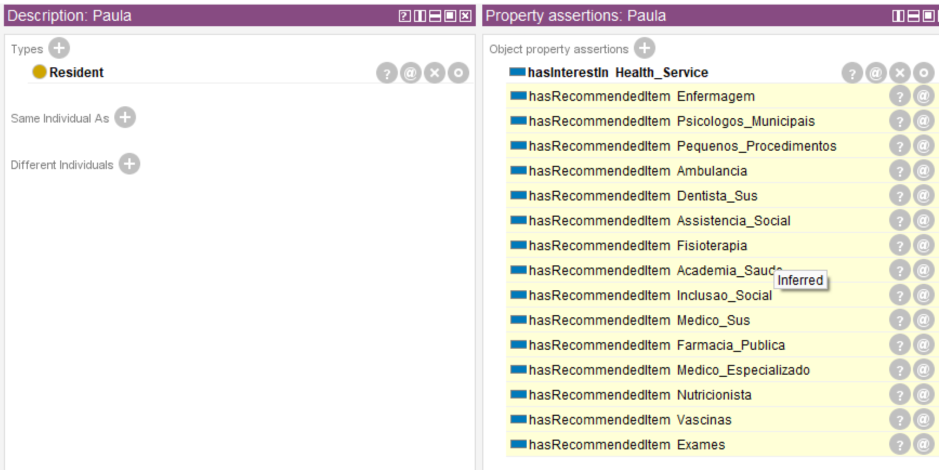

Figure 6. Inferred Rule of Health Service POIs

The visitor who is interested in health services and receives the following recommended items: nursing, psicologos_municipais, pequenos_procedimentos, ambulancia, dentista_sus, assistencia_social, physiotherapy, academia_saude, inclusao_social, medico_sus, farmacia_publica, medico_especializado, nutritionist, vascinas, exams. To execute SWRL rules, an automated reasoner named Pellet was used, as shown in figures 4 and 6, the reasoner tests and infers the data of the rules through the inference engine in the ontological basis. The rule presented below recommends to the user the POIs that he has stated he has an interest (Tourism for example). In addition, this rule filters the POIs that are close to the POI that the user is currently in. For example, what are the POIs that are close to the quartz cave that the user is currently in and that is of interest to him. The object property nearOF declared in the ontology that near the Mother Church Of Our Lady of Health (nearOf) is in the central square with the monument of the priest who founded the site. Therefore, these two would be recommended together since the user is in the Our Lady of Health Matrix.

Person(?p) ^ **Subject**(?s) ^ **POI**(?poi) ^
hasInterestIn(?p, ?s) ^ contemplates(?poi, ?s) ^
hasLocation(?p, ?l) ^ nearOf(?poi, ?l) -> **hasRecommendedItem(?p, ?poi)**

In the sequence we also present the rules that filter within the ontology whether the person is child, adult or senior. Based on this information we may perform filters by interests identifying age:

This rule filters if the person is adult:
swrlb:greaterThan(?age, 19) ^ swrlb:lessThan(?age, 59) ^ hasAge(?p, ?age) ^ Person(?p) -> Adult(?p)

This rule filters if the person is senior:
hasAge(?p, ?age) ^ swrlb:greaterThan(?age, 59) ^ Person(?p) -> Senior(?p)

This rule filters whether the person is child:
swrlb:greaterThan(?age, 0) ^ hasAge(?p, ?age) ^ swrlb:lessThan(?age, 19) ^ Person(?p) ->Child(?p)

4 Conclusion

In this work, an ontology-based recommendation system was proposed to filter the best points of interest based on the person's location. The system was evaluated through a case study involving a city in the southern region of Brazil, Cotiporã. The city data were used to popular one ontology and, from SWRL rules, recommendations were generated, demonstrating the potential of an ontology in assisting a person in a city. Two SWRL rules were tested, one for points of interest in tourism and one for health services. As future work, itis necessary to validate the approach developed with visiting citizens and residents of the city and to use the system to generate recommendation of other points of interest.

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