

Conversion of Physical Quantity and its Application

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Abstract. In this presentation, we show the design of a vocabulary set for the conversion of physical quantities and a prototype application using it. The vocabulary consists of *facts* and *rules* and is formalized with the W3C Web Ontology Language (OWL) under a resource description framework (RDF). Here, *facts* are physical quantities of things such as the weight of the Statue of Liberty, and *rules* are conversion relations such as “the energy of a cup of rice is 200 kilocalories.” The conversion between quantities is done by SPARQL query. An application was developed to educate users about global warming. The application converts different physical quantities under various circumstances such as the amount of gasoline a car burns, the weight of waste materials, and so on into CO₂ emissions.

1 Introduction

Conversion to other quantities is often used as a method of expressing physical quantities that are difficult to understand intuitively. For example, if you eat a cup of rice, you have to run 5 km to consume the energy in it, because the energy of both is almost equal. Likewise, health and welfare authorities can encourage people to exercise by giving them information on converting the energy expended during movement into the number of calories burned.

Our research aims to automatically perform such conversions by resource description framework (RDF). In our presentation, we show the design of an ontology for the conversion of one physical quantity into equivalent physical quantities by using RDF examples. The ontology consists of two parts. One is the conversion relations (rules), e.g., for expressing that the amount of CO₂ emitted during the combustion of 1 kl of gasoline is 2.32 kg. The other is the physical quantities of the things converted (facts), e.g., for expressing that the round trip distance from the Earth to the Moon at the average distance between the two bodies is 770,000 km. Through the combination of rules and facts, SPARQL query enables the physical quantity of the conversion to be found automatically. The presentation also describes a prototype application for educating users about global warming.

2 Ontology for Conversion

The ontology consists of conversion relations and the physical quantities of things. The conversion relation is called a *rule* and expresses the relationships between two physical quantities such as “the CO₂ emitted during the combustion of 1 kl of gasoline is 2.32

kg.” The physical quantity of things is called a *fact* and expresses, e.g., that the round trip distance from the Earth to the Moon at the average distance between the two bodies is 770,000 km. An ontology of units of measurement (OM)[2] and related concepts[3] are used as the basis of unit conversion. The OM is an RDF that expresses meanings such as definitions and dimensions for various units such as kg, m, and t.

```
@prefix om: <http://www.wurvoc.org/vocabularies/om-1.8/> .
@prefix un: <http://lod4all.net/property/unit/> .

<http://lod4all.net/resource/unit/car_gas_to_distance>
  rdf:type <http://lod4all/ontology/unit/conversion> ;
  un:coefficient "20"^^xsd:decimal;
  un:numerator "Distance"@en ;
  un:denominator "Gasolin"@en ;
  un:numerator_unit om:kilometre ;
  un:denominator_unit om:litre ;
  un:event "Running_of_the_car"@en .

<http://ex.com/unit/resource/burn_gas_to_co2>
  rdf:type <http://lod4all/ontology/unit/conversion> ;
  un:coefficient "2.32"^^xsd:decimal;
  un:numerator "CO2" ;
  un:denominator "Gasolin"@en ;
  un:numerator_unit om:tonne ;
  un:denominator_unit om:kilolitre ;
  un:event "combustion"@en .
```

List 1. Conversion factor(Rule)

List 1 contains two *rules*. Car_gas_to_distance is the conversion coefficient (fuel consumption) of gasoline in regards to the distance driven by a car, with a value of 20. Burn_gas_to_co2 expresses the conversion coefficient between the amount of CO₂ emitted and the amount of gasoline combusted. The CO₂ emitted due to the combustion of 1kl of gasoline is 2.32 kg.

```
@prefix om: <http://www.wurvoc.org/vocabularies/om-1.8/> .
@prefix un: <http://lod4all.net/property/unit/> .

<http://ex.com/unit/resource/W016>
  rdf:type <http://lod4all.net/ontology/unit/object> ;
  un:value "770000"^^xsd:float;
  un:unit om:kilometre ;
  un:name "Round-trip_distance_to_the_moon"@en ;
  un:kazoe "distance"@en .
```

List 2. Physical quantity(Fact)

List 2 is representing a *fact*. The *fact* is that the round trip distance from the Earth to the Moon at the average distance between the two bodies is 770,000 km.

Fig.1 shows a combination of the coefficient of emissions due to the combustion of gasoline and the fuel consumption of a car. In this example, gasoline in the denominator

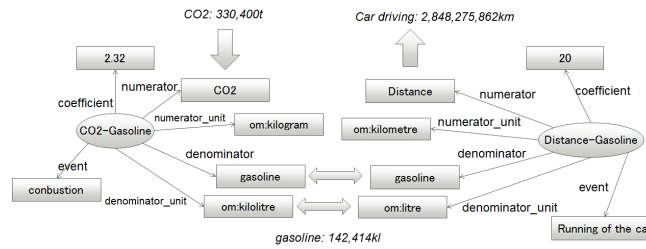


Fig. 1. Examples of combination of conversion factors

in the “CO₂ -Gasoline” coefficient and gasoline in the denominator in the “Distance-Gasoline” coefficient match, and the unit can be converted between kl and l, thus showing that combinations are possible. In this way, the calculation of convertible quantities and conversion relations can be automated by giving the quantities and units (“CO₂ emissions” and “tons”) as input. Using the combined rules and facts which correspond to various amounts, it is possible to generate expressions such as “X times the earth’s circumference.”

Using the combination in Fig. 1, a Japanese city’s CO₂ emissions of 330.4 kt are calculated as the same amount a car emits when using 155,000,000 liters of gasoline, which would enable the car to make 1,699 round trips to the Moon.

3 CO₂ emissions conversion application

On the basis of the ontology, we developed a prototype application that relates different physical quantities under various circumstances to CO₂ emissions, as shown in Fig. 2. This application has two functions. First, it simulates reductions in physical quantities on the basis of a conversion relation. Second, it calculates reductions in CO₂ emissions in relation to the reduced physical quantities.

Pressure, energy, temperature, angular velocity, acceleration, time, power factor, magnetic field, mass, frequency, volume, force, voltage, electric resistivity, current, length, speed, and specific heat capacity are expressed in tabular form in Wikipedia. By analyzing the structure of this table, those physical quantities are systematically extracted. As conversion relations, CO₂ emissions from the combustion of gasoline, the fuel consumption of cars, CO₂ emissions due to the combustion of garbage, the specific gravity of waste, CO₂ emissions for the generation of electric power, and the power consumption of air conditioners are used. The rules are described by their authors.

The application converts CO₂ emissions from the given circumstances and categorizes them into three kinds of quantities: amount of garbage combusted, amount of power consumed by air conditioners, and distance in terms of Earth circumferences driven in a car. As for amount of garbage combusted, the application converts CO₂ emissions into masses and volumes by using burned waste and the specific gravity of the waste as conversion relations. Conversions to physical quantities could be for example “CO₂ emitted when burning garbage of a weight corresponding to X times the

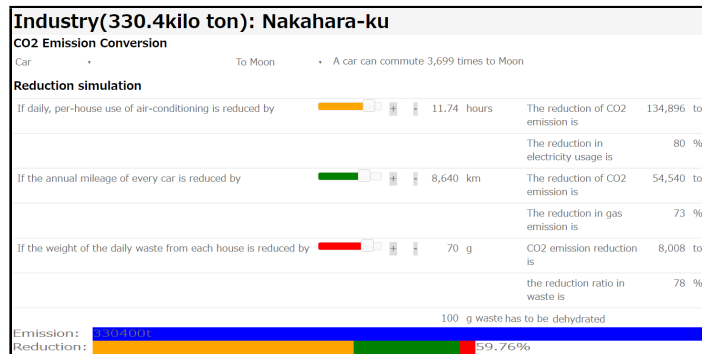


Fig. 2. An application system of green gas emission conversion

Eiffel Tower” or “CO₂ emitted when burning garbage of a weight equivalent to Y times Wembley Stadium.” As for the power consumed by air conditioners, CO₂ emissions from power stations and air conditioner power consumption are used as conversion relations, and the emissions are converted into air conditioner usage time. As for car travel distance, CO₂ emissions from gasoline-burning and the fuel efficiency of cars are used as conversion relations, and the emissions are converted into quantities representing the Earth’s circumference or the average distance between the Earth and the Moon.

4 Summary

This article described the design of a vocabulary set for the conversion of physical quantities and a prototype application using it. The vocabulary is formalized with OWL, and RDF is used for representing *facts* and *rules*. *Facts* are physical quantities of things such as the weight of the Statue of Liberty, and *rules* are conversion relations such as “the energy of a cup of rice is 200 kilocalories.” The conversion between quantities is done by a simple SPARQL query. An application was developed to educate users about global warming. The application converts different physical quantities such as the amount of gasoline a car burns, the weight of waste materials, and so on into CO₂ emissions. Currently, 300 facts and 40 rules are available as a dataset from LOD4ALL¹. The graph name is <<http://lod4all.net/graph/unit>>. Rules and facts are extracted with a tool based on [1]. We are continuing to extract more facts and rules from the Internet.

References

1. Pasupat, P., Liang, P.: Compositional semantic parsing on semi-structured tables (2015)
2. Rijgersberg, H., van Assem, M., Top., J.: wurvoc.org Ontology of units of Measure (OM), <http://www.wurvoc.org/vocabularies/om-1.8/>
3. Rijgersberg, H., van Assem, M., Top., J.: Ontology of units of measure and related concepts (2012)

¹ <http://lod4all.net/>