Validating statistical index data represented in RDF using SPARQL queries

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Abstract

In this position paper we describe an approach to validate statistical data representing index computations in RDF using SPARQL queries.

1 Introduction

Publishing statistical data is a promising domain where linked data approaches con offer a numer of advantages.

TODO: a paragraph about linked data and RDF

The SPARQL [4] query language has been a successful technology to increase the adoption RDF. The current SPARQL 1.1 [3] has added new expressivity levels.

TODO: Talk about index data in general TODO: Talk a little bit about the web index project, link to our publication

TODO: Add an overview of our approach...

2 Example data and Index computation process

TODO: A small screen capture

3 Data Model and Computex Ontology

TODO: Talk about the Computex ontology of statistical computations

3.1 Computex Ontology

The *Computex*[1] vocabulary defines terms related to the computation of statistical index data. It is an specialization of the RDF Data Cube vocabulary [2] and is compatible with it.

[1] `http://purl.org/weso/computex`

List of terms:

- **Indicator**
- **Concept**
- **Observation**. An observation. It contains at least values for the properties: cex:value, cex:indicator and cex:concept
- **Computation** we have declared the main computation types that we have needed for the WebIndex project, which have been summarized in table 1. That list of computation types is not exhaustive and can be further extended in the future.
- **WeightSchema** a weight schema for a list of indicators.

Table 1: Some types of statistical computations

Computation	Description	Properties
Mean	Mean of a set of observations	cex:observation
Increment	Increment an observation by a given amount	cex:observation amount
Raw	No computation. Raw value obtained from external source.	
Copy	A copy of another observation	cex:observation
Z-score	A normalization of an observation using the values from a Slice.	cex:observation cex:slice
Ranking	Position in the ranking of a slice of observations.	cex:observation cex:slice
AverageGrowth(N)	Expected average growth of N observations	cex:observations a collection of observations
WeightedMean	Weighted mean of an observation	cex:observation cex:slice cex:weightSchema

4 Validation approach

The validation approach was inspired by the integrity constraint specification proposed by the RDF Data Cube vocabulary which employs a set of SPARQL ASK queries to check the integrity of RDF Data Cube data. Although SPARQL ASK queries provide a good means to check the integrity, in practice their boolean nature does not offer too much help when a file does not validate. To solve that issue, we defined CONSTRUCT queries which, in case of error, construct an error message and a list of error parameters that can help to spot the problematic data.

We have also transformed the ASK queries defined in the RDF Data Cube vocabulary to CONSTRUCT queries. For example, SPARQL construct query to validate the RDF Data Cube integrity constraint 4 (IC-4) is:

```
CONSTRUCT {
 [ a cex:Error ;
   cex:errorParam
         [cex:name "dim"; cex:value ?dim ] ;
   cex:msg
    "Every Dimension must have a declared range" . ]
} WHERE {
  ?dim a qb:DimensionProperty .
  FILTER NOT EXISTS { ?dim rdfs:range [] }
}
```

In order to make our error messages compatible with EARL [1], we have defined cex:Error as a subclass of earl:TestResult and declared it to have the value earl:failed for the property earl:outcome.

We have also created our own set of SPARQL Construct queries to validate the *Computex* vocabulary terms, specially the computation of index data.

For example, the following query validates that every observation has at most one value.

```
CONSTRUCT {
 [ a cex:Error ;
      cex:errorParam
            [cex:name "obs" ; cex:value ?obs ] ,
            [cex:name "value1"; cex:value ?value1 ],
            [cex:name "value2"; cex:value ?value2 ] ;
     cex:msg "Observation has two different values" . ]
} WHERE {
 ?obs a qb:Observation .
 ?obs cex:value ?value1 .
 ?obs cex:value ?value2 .
 FILTER ( ?value1 != ?value2 )
}
```

Using this approach, we have been able to develop more expressive validations. For example, we were able to validate that an observation was obtained as the mean of other observations.

```
CONSTRUCT {
 [ a cex:Error ;
   cex:errorParam
  [cex:name "obs" ; cex:value ?obs ] ,
  [cex:name "val"; cex:value ?val ],
  [cex:name "?mean"; cex:value ?mean ] ;
  cex:msg "Mean value does not match" ] .
```

```
} WHERE {
  ?obs a qb:Observation ;
        cex:computation ?comp ;
        cex:value ?val .
  ?comp a cex:Mean .
  { SELECT (AVG(?value) as ?mean) ?comp WHERE {
      ?comp cex:observation ?obs1 .
          ?obs1 cex:value ?value ;
  } GROUP BY ?comp }
 FILTER( abs(?mean − ?val) > 0.0001)
}
```

Show some queries.

5 Expressivity limits of SPARQL queries

Validating statistical computations using SPARQL queries offered a good exercise to check SPARQL expressivity. Although we were able to express most of the computation types. Some of them had to employ functions that are not part of the SPARQL 1.1 standard or had to be defined in a limited way. In this section we review the main difficulties.

- The Z-score of a value x_i is defined as $\frac{x-\bar{x}}{\sigma}$ where $\bar{x}$ is the mean and $\sigma = \sqrt{\frac{\sum_{i=1}^{N}(\bar{x}-x_i)^2}{N-1}}$ is the standard deviation. To validate that computation using SPARQL queries, it is necessary to employ the sqrt function. This function is not available in SPARQL 1.1 although some implementations like Apache Jena ARQ provide it.

- In order to validate the ranking of an observation (in which position it appears in a Slice), we used the GROUP_CONCAT SPARQL 1.1 function to group the ordered list of observations. However, when one wants to search the observation to rank in that list, SPARQL does not offer a function to calculate the position of a substring in a string[2], so we had to divide the length of the substring before the concept's name by the length of the concept's name. This solution only works when all the concept's name have the same length.

- average growth

6 Conclusions and Future Work

Using SPARQL queries to validate and compute index data seems a promising use case for linked data applications.

TODO: Future work

[2]This function is called strpos in PHP or indexOf in Java

TODO: Automatic index computation TODO: Performance and real time updating of index computations TODO: Visualization of computed values

References

[1] Evaluation and report language EARL 1.0 schema. http://www.w3.org/TR/EARL10-Schema/, 2011. W3C Working Draft.

[2] The RDF data cube vocabulary. http://www.w3.org/TR/vocab-data-cube/, 2013. W3c Candidate Recommendation.

[3] S. Harris and A. Seaborne. SPARQL 1.1 query language. http://www.w3.org/TR/sparql11-query/, 2013.

[4] E. Prud'hommeaux and A. Seaborne. SPARQL query language for RDF. http://www.w3.org/TR/rdf-sparql-query/, 2008.