

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 can offer a number of advantages.

TODO: a paragraph about linked data and RDF

The SPARQL [4] query language has been a successful technology to increase the adoption of 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 a 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	<code>cex:observation</code>
Increment	Increment an observation by a given amount	<code>cex:observation</code> <code>amount</code>
Raw	No computation. Raw value obtained from external source.	
Copy	A copy of another observation	<code>cex:observation</code>
Z-score	A normalization of an observation using the values from a Slice.	<code>cex:observation</code> <code>cex:slice</code>
Ranking	Position in the ranking of a slice of observations.	<code>cex:observation</code> <code>cex:slice</code>
AverageGrowth(N)	Expected average growth of N observations	<code>cex:observations</code> a collection of observations
WeightedMean	Weighted mean of an observation	<code>cex:observation</code> <code>cex:slice</code> <code>cex:weightSchema</code>

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 $\frac{x_i - \bar{x}}{\sigma}$ 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.
- ranking need better XPath functions
- 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

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.
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- [4] E. Prud'hommeaux and A. Seaborne. SPARQL query language for RDF.
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