Ontology Evaluation and Ranking using OntoQA

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Outline

- Why ontology evaluation?

- OntoQA
  - Overview
  - Metrics
  - Overall Score
  - Results

- Enhancements
Having several ontologies to choose from, users often face the problem of selecting the ontology that is most suitable for their needs.

Ontology developers need a way to evaluate their work.
OntoQA

- A suite of metrics that evaluate the content of ontologies through the analysis of their schemas and instances in different aspects.

- It has been cited over 170 times.

- OntoQA is
  - tunable
  - requires minimal user involvement
  - considers both the schema and the instances of a populated ontology.
OntoQA Usage Scenario 1
OntoQA Usage Scenario 2
I. Schema Metrics

- Address the design of the ontology schema.

- Schema could be hard to evaluate: domain expert consensus, subjectivity etc.

- Metrics:
  - Relationship diversity
  - Inheritance depth
I. Schema Metrics

- **Relationship diversity**
  - This measure differentiates an ontology that contains mostly inheritance relationships ($\approx$ taxonomy) from an ontology that contains a diverse set of relationships.

- **Schema Depth**
  - This measure describes the distribution of classes across different levels of the ontology inheritance tree

\[
RD = \frac{|P|}{|H| + |P|}
\]

\[
SD = \frac{|H|}{|C|}
\]
II. Instance Metrics

- Evaluate the placement, distribution and relationships between instance data

- Can indicate the effectiveness of the schema design and the amount of knowledge contained in the ontology.
II. Instance Metrics

- Overall KB Metrics
  - This group of metrics gives an overall view on how instances are represented in the KB.

- Class-Specific Metrics
  - This group of metrics indicates how each class defined in the ontology schema is being utilized in the KB.

- Relationship-Specific Metrics
  - This group of metrics indicates how each relationship defined in the ontology schema is being utilized in the KB.
Overall KB Metrics

- **Class Utilization**
  - Evaluates how classes defined in the schema are being utilized in the KB.

- **Class Instance Distribution**
  - Evaluates how instances are spread across the classes of the schema.

- **Cohesion (connectedness)**
  - Used to discover instance “islands”.

\[ CU = \frac{|C|}{|C|} \]

\[ CID = \text{StdDev}(\text{Inst}(Ci)) \]

\[ Coh = |CC| \]
Class-Specific Metrics

- **Class Connectivity (centrality)**
  - This metric evaluates the importance of a class based on the relationships of its instances with instances of other classes in the ontology.
  
  \[ \text{Conn}(C_i) = |NIREL(C_i)| \]

- **Class Importance (popularity)**
  - This metric evaluates the importance of a class based on the number of instances it contains compared to other classes in the ontology.
  
  \[ \text{Imp}(C_i) = \frac{|\text{Inst}(C_i)|}{|\text{KB}(CI)|} \]

- **Relationship Utilization**
  - This metric evaluates how the relationships defined for each class in the schema are being used at the instances level.
  
  \[ \text{RU}(C_i) = \frac{|\text{IREL}(C_i)|}{|\text{CREL}(C_i)|} \]
Relationship-Specific Metrics

- Relationship Importance (popularity)
  - This metric measures the percentage of instances of a relationship with respect to the total number of relationship instances in the KB.

\[
Imp(R_i) = \frac{|Inst(R_i)|}{|KB(RI)|}
\]
Ontology Score Calculation

\[ Score = \sum W_i \times Metric_i \]

- **Metric\(_i\):**
  - \{Relationship diversity, Schema Depth, Class Utilization, Cohesion, Avg(Connectivity(C\(_i\))), Avg(Importance(C\(_i\))), Avg(Relationship Utilization(C\(_i\))), Avg(Importance(R\(_i\))), #Classes, #Relationships, #Instances\}

- **W\(_i\):**
  - Set of tunable metric weights
### Results

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Ontology URL</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td><a href="http://ebiquity.umbc.edu/ontology">http://ebiquity.umbc.edu/ontology</a> confernece.owl</td>
</tr>
<tr>
<td>II</td>
<td><a href="http://kmi.open.ac.uk/semanticweb/ontologies/owl/aktive-portal-ontology-latest.owl">http://kmi.open.ac.uk/semanticweb/ontologies/owl/aktive-portal-ontology-latest.owl</a></td>
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<tr>
<td>III</td>
<td><a href="http://www.architesturez.in/+-c--/caad.3.0.rdf.owl">http://www.architesturez.in/+-c--/caad.3.0.rdf.owl</a></td>
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<tr>
<td>IV</td>
<td><a href="http://www.csd.abdn.ac.uk/~cmckenzi/playpen/rdf/akt_ontology_LITE.owl">http://www.csd.abdn.ac.uk/~cmckenzi/playpen/rdf/akt_ontology_LITE.owl</a></td>
</tr>
<tr>
<td>V</td>
<td><a href="http://www.mindswap.org/2002/ont/paperResults.rdf">http://www.mindswap.org/2002/ont/paperResults.rdf</a></td>
</tr>
<tr>
<td>VI</td>
<td><a href="http://owl.mindswap.org/2003/ont/owlweb.rdf">http://owl.mindswap.org/2003/ont/owlweb.rdf</a></td>
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<tr>
<td>VII</td>
<td><a href="http://139.91.183.30:9090/RDF/VRP/Examples/SWPGRdfs">http://139.91.183.30:9090/RDF/VRP/Examples/SWPGRdfs</a></td>
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<td>VIII</td>
<td><a href="http://www.lehigh.edu/~zhp2/2004/0401/univ-bench.owl">http://www.lehigh.edu/~zhp2/2004/0401/univ-bench.owl</a></td>
</tr>
</tbody>
</table>

**Swoogle Results for "Paper"**
OntoQA Results for "Paper" with default metric weights
OntoQA Results for "Paper" with metric weights biased towards larger schema size
<table>
<thead>
<tr>
<th>Ontology</th>
<th>OntoQA Rank</th>
<th>Average User Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>2</td>
<td>9</td>
</tr>
<tr>
<td>II</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>III</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>IV</td>
<td>1</td>
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<td>V</td>
<td>8</td>
<td>8</td>
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<tr>
<td>VI</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>VII</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>VIII</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>IX</td>
<td>9</td>
<td>3</td>
</tr>
</tbody>
</table>

Pearson’s Correlation Coefficient = 0.80
Comparison to Other Approaches

<table>
<thead>
<tr>
<th>Approach</th>
<th>User Involvement</th>
<th>Ontologies</th>
<th>Schema/KB</th>
</tr>
</thead>
<tbody>
<tr>
<td>[1]</td>
<td>High</td>
<td>Entered</td>
<td>Schema</td>
</tr>
<tr>
<td>[4]</td>
<td>Low</td>
<td>Entered</td>
<td>Schema</td>
</tr>
<tr>
<td>[6]</td>
<td>Low</td>
<td>Crawled</td>
<td>Schema</td>
</tr>
<tr>
<td>[7]</td>
<td>Low</td>
<td>Crawled</td>
<td>Schema</td>
</tr>
<tr>
<td>[8]</td>
<td>Low</td>
<td>Entered</td>
<td>Schema</td>
</tr>
<tr>
<td>[9]</td>
<td>Low</td>
<td>Entered</td>
<td>Schema</td>
</tr>
<tr>
<td>OntoQA</td>
<td>Low</td>
<td>Enter/Crawl</td>
<td>Schema + KB</td>
</tr>
</tbody>
</table>
Possible Enhancements

- Enable the user to specify an ontology library (e.g. OBO) to limit the search in ontologies that exist in that specific library.

- Use BRAHMS instead of Sesame as a data store since BRAHMS is more efficient in handling large ontologies that are common in bioinformatics.
References

Thank you