Linking and Negotiating Uncertainty Theories over Linked Data

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• Web-Instrumented Man-Machine Interactions, Communities & Semantics
  : AI in bridging social semantics and formal semantics on the Web

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  – Fabien Gandon
Outline

• Introduction
• Uncertainty Representation
• Translating & Negotiating Uncertainty
• Perspectives
• Conclusion
“It’s too easy for misinformation to spread on the web”

- Tim Berners-Lee, 2017 *

* https://webfoundation.org/2017/03/web-turns-28-letter/
What is the height of Stefano Tacconi, according to dbpedia?

- 1.88 m - en.dbpedia
- 1.93 m - fr.dbpedia
- 192 cm - pl.dbpedia
- 188 cm - it.dbpedia
Introduction

- Invalidity
- Incompleteness
- Inconsistentency
- **Undecidability**
- Context ignorance
- Bias, Subjectivity
- Etc.
Uncertainty Representation

- It’s **metadata**, yet still, **data**
- Indicates **ignorance**
- Linked to **undecidability**
- Follows a **theory** (Approach)

Uncertainty Representation

**mUnc Vocabulary**

![Diagram showing the mUnc vocabulary structure.](#)

* ns.inria.fr/munc/
Uncertainty Representation

Uncertainty metadata

- a set of pairs \((\text{feature, value})\): one or a set of compatible uncertainty theories.
- Theories and features are represented by resources.
- The Calculii is represented as a resource, using LDScript language*

```sparql
ex:S1 munc:hasMeta [ 
  a munc:Uncertainty; 
  prob:probabilityValue 0.7 
].

prob:Probability a munc:UncertaintyApproach; 
munc:hasUncertaintyFeature prob:probabilityValue; 
munc:hasUncertaintyOperator prob:and, prob:or, prob:not.

prob:probabilityValue prob:and prob:multIndependentProb.

function prob:multIndependentProb(?p1, ?p2){ 
  ?p1 * ?p2
}
```

* ns.inria.fr/sparql-extension/*
Example: Uncertainty Theory

- Functions defining the *calculii* of uncertainty features
Example: @metadata

- Transparent integration
- Corese Semantic Web engine
  - LDScript
  - Query visitors
  - Linked Functions
  - Workflows

function munc:metaList(?xT, ?xC){
  let(
    SELECT ?xT ?xC (group_concat(?FV;separator="-") as ?metaD) WHERE {
      {
        SELECT ?xT ?xC (CONCAT(?xF,"=",?xV) AS ?FV) WHERE {
          OPTIONAL {?xF ?xF ?xV2}
          ?xF rdfs:subPropertyOf munc:uncertaintyFeature.
          ?xF ex:and ?xFFunction.
          BIND(IF(BOUND(?xV2), funcall(?xFFunction,?xV1,?xV2), ?xV1) AS ?xV)
        } GROUP BY ?xT ?xC
      }
    UNION {
      SELECT ?xT ?xC (CONCAT(?xF,"=",?xV) AS ?FV) WHERE {
        ?xT ?xF ?xV
        ?xF rdfs:subPropertyOf munc:uncertaintyFeature
        FILTER NOT EXISTS {?xC ?xF ?xV2}
      } GROUP BY ?xT ?xC
    }
    )

)(
  ?metaD
)
}

Results: « Feature1 = Value1, Feature2 = Value2, ... »
Example: @metadata

- Transparent integration
- Corese Semantic Web engine
  - LDScript
  - Query visitors
  - Linked Functions
  - Workflows

prefix ex: <http://example.org/>.

@metadata
SELECT ?g ?s ?p ?o WHERE {
  graph ?g {?s ?p ?o}
}

Results:
:subject, :predicate, :Object, « Feature1 = Value1, Feature2 = Value2, ... »
Contextualization

Representing Uncertainty

- S1
  - G1
  - G2

- S2

- S3
  - G3
  - G4

- S1
  - C11
  - C12

- S2
  - C20

- S3
  - C30
  - C31
  - C32

- C
  - Named Graph
  - Sentence
  - Metadata
  - Context
Example: Contextualization

- Each context has its own metadata
- Sentence inherits context

<table>
<thead>
<tr>
<th>:SciFi</th>
<th>:Bio</th>
</tr>
</thead>
<tbody>
<tr>
<td>:Apple :hasColor :Blue</td>
<td>:Apple :hasColor :Red</td>
</tr>
<tr>
<td>:Apple :hasColor :Green</td>
<td>:Apple :hasColor :Green</td>
</tr>
<tr>
<td>:Apple :hasColor :Green</td>
<td>:Apple :hasColor :Green</td>
</tr>
<tr>
<td>:SciFi :probabilityValue 0.3</td>
<td>:Bio  :probabilityValue 0.7</td>
</tr>
<tr>
<td>:Bio :probabilityValue 0.7</td>
<td></td>
</tr>
</tbody>
</table>
Example: Practice

@metadata
SELECT ?color where {:Apple :hasColor ?color}

Results:
1: (:Red, (0.7)),
2: (:Green, $U_2 = 1,\text{dbpedia}$) xor (0.3) xor (prob:functionX(1,0.3)),
3: (:Yellow, (0.7)),
4: (:Blue, (0.3))

- Selection based on meta-mapping modes
Translating & Negotiating Uncertainty

Querying

Translation

Negotiation

Query: $S_1$, $S_2$, $mS_1$, $mS_2$

Mapping: $mS_x$, $S_x$

Trace: $S_x$ from $C_x$ have $\{v \text{ for feature } k\}$
Translating & Negotiating Uncertainty

**mUnc Vocabulary**

- **World**
- **Meta**
- **Sentence**

**mUnc Translatability Extension**

- **Translation Function**
- **Uncertainty Approach**
- **Uncertainty Value**
- **Uncertainty Arts**
- **Uncertainty Operation**
- **Uncertainty Feature**

**mUnc Translatability Extension**

- **munc:translateFrom**
- **munc:translateTo**
- **munc:hasFullTranslation**
- **munc:hasIdealTranslation**
- **munc:hasTranslation**

---

**Querying**

- **Translation**

**Negotiation**
Translating & Negotiating Uncertainty

Choice of a translation

- loss in term of order semantics
- loss in value
Example: CONNEG

- Specify uncertainty in parameter linked to the format
  - GET /some/resource HTTP/1.1
    Accept: text/turtle;uncertainty="http://example.com/Probability";q=0.8,
    text/turtle;uncertainty="http://example.com/Possibility";q=0.2;

- Use uncertainty as a profile: prof-Conneg
  - GET /some/resource HTTP/1.1
    Accept: text/turtle;q=0.8;profile="prob:Probability",
    text/turtle;q=0.2;profile="poss:Possibility"
  - HEAD /some/resource HTTP/1.1
    Accept: text/turtle;q=0.9,application/rdf+xml;q=0.5
    Link: <http://example.com/Probability>; rel="profile" (RFC 6906)
  - GET /some/resource HTTP/1.1
    Accept: text/turtle
    Prefer: profile="prob:Probability" (RFC 7240)
Translating & Negotiating Uncertainty

Querying

Translation

Negotiation

GET /some/resource HTTP/1.1
Accept: text/turtle; uncertain="http://example.org/probability"; q=0.9

SERVER

HTTP/1.1 200 OK
Content-Type: text/turtle; uncertain=http://example.org/probability

HTTP/1.1 200 OK
Content-Type: text/turtle; uncertain=http://example.org/possibility; translation=full

HTTP/1.1 200 OK
Content-Type: text/turtle; uncertain=http://example.org/possibility; default=true

Information exist and is served
Information exist within another theory
Information do not exist under the requested theory, no available translations

Information is translated and served (Full, ideal, or normal)
Default theory is served
Perspectives

- Weighted contexts
  ... and why not, nested contexts
- Uncertainty dictionary
  - Theories, features and calculus
  - Translations
- Triple-Stored Calculi (ex: STATO + R)
- Uncertainty as an application of RDF* *

Conclusion

- URW3-XG
- PROV-O
- mUnc

- **Stephano Tacconi** is an Italian soccer player (1.88m)
Thank You

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