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Using ontologies and fuzzy relations in multimedia personalization

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Overview

- **Semantic multimedia personalization**
- *Previous work:*
  - developed algorithms to address fuzzy relations
  - addressed knowledge representation
  - addressed thematic categorization
  - addressed user modeling
- *In this paper:*
  - Integrate **ontologies** in the knowledge modeling approach
  - Integrate and represent **fuzzy relations** in the knowledge model
  - Explain how to **combine** these diverse algorithms and methodologies
  - Present exploitation of the model within two popular **applications**:
    - **Topic extraction**
    - **User modeling**

Introduction

- *10 years ago:*
  - Information Retrieval (IR), text retrieval -> text community
  - Multimedia analysis, image and video processing -> multimedia community
  - Semantic gap
- *Nowadays:*
  - Semantic gap still there!
  - The amount of accessible, processable and searchable data is growing at a huge pace
  - 2 extra parameters are in play:
    - **Personalization**
    - **Semantics**

Introduction

- Ontologies
  - model knowledge
  - formal
  - solid basis for semantic representation and operations
- Idea: integrate ontologies with:
  - Real-life interpretation, i.e. fuzziness
  - MPEG-7 derived (fuzzy) binary relations
- Extract topics of multimedia documents
- Extract user profiles

Contextual Knowledge Representation (1/4)

- Ontologies may be described as:

$$O = \{C, \{R_{c_i,c_j}\}\}, i, j = 1..n, \ i \neq j \quad R_{c_i,c_j} : C \times C \rightarrow \{0,1\}, i = 1\ldots n$$

  O : an ontology

  C : set of concepts it describes and

  R_{c_i,c_j} : semantic relation amongst two concepts $c_i, c_j \in C$

- Define ***ontological context*** in the means of fuzzy taxonomic ontological relations:

$$F(O) = \{C, \{r_{c_i,c_j}\}\}, \ i, j = 1..n, \ i \neq j \quad F(R_{c_i,c_j}) = r_{c_i,c_j} : C \times C \rightarrow [0,1]$$

  F(O): a “fuzzified” ontology

  C : set of all possible concepts it describes and

  $F(R_{c_i,c_j}) = r_{c_i,c_j}$ denotes a **fuzzy** relation amongst two concepts

Contextual Knowledge Representation (2/4)

- Enhance RDF, being a standardized, graph-modeled language, with novel characteristics like ***reification***.
  - Reification makes a statement about the statement, which contains the degree information
- The proposed representation is a graph:
  - Every node represents a concept
  - Each edge between 2 nodes forms a contextual relation between the concepts
  - Each edge has an associated degree of confidence, implementing fuzziness

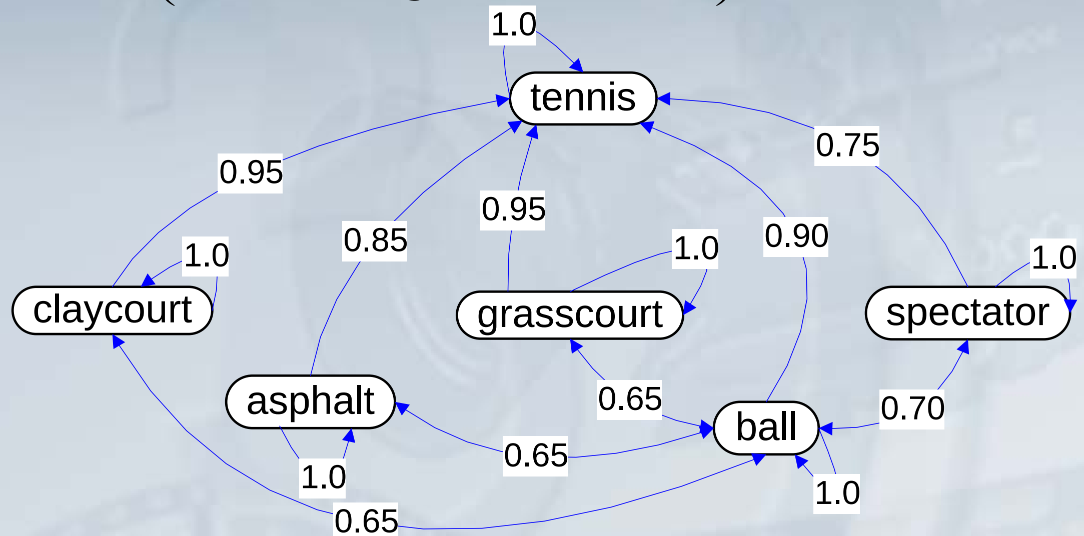
Contextual Knowledge Representation (3/4)

```
<rdf:Description rdf:about="#s1">
    <rdf:subject rdf:resource="&dom;tennis"/>
    <rdf:predicate rdf:resource="&dom;Part"/>
    <rdf:object>rdf:resource="&dom;ball"</rdf:object>
    <rdf:type rdf:resource="http://www.w3.org/1999/02/22-rdf-syntax-ns#Statement"/>
    <context:Part rdf:datatype="http://www.w3.org/2001/XMLSchema#float">
      0.75</context:Part>
</rdf:Description>
```

- Utilization of any type of real-life fuzzy relations. Herein, MPEG-7 derived:
  - ***Specialization (Sp)*** ***Part (P)*** ***Property (Pr)***
  - ***Example (E)*** ***Context (Ct)*** ***Interpretation (In)***
  - ***Member (M)*** ***Agent (Ag)*** ***Result (Res)***
  - ***Location (Loc)***
- Highly descriptive knowledge model
  - contain a large number of **distinct** and **diverse** relations among concepts
  - side effect: information **scattering** => **combination** needed

Contextual Knowledge Representation (4/4)

- Finally: $$T = Tr^t \begin{pmatrix} Sp \cup P^{-1} \cup Pr^{-1} \cup E \cup Ct \cup \\ In \cup M \cup Ag \cup Res \cup Loc \end{pmatrix}$$



- Introduce an efficient algorithm for the needs of transitive closure of ontological knowledge representations, based on the sparse nature of ontological relations
- Use inverse relation functionality, according to the semantics of its relation, defined in the MPEG-7 standard

Topic Extraction

- Ultimate goal:
  - Estimation of higher level concepts related to each multimedia document, i.e. topic extraction
- A concept may be related to multiple, unrelated topics
- A multimedia document may be related to multiple, unrelated topics
- The list of concepts contained in a multimedia document may have been created in an automated manner. Thus, existence of random and therefore misleading concepts cannot be excluded.
- Semantic ontological relations are a matter of degree. Therefore, correlation between a document and a topic is also a matter of degree.

Topic Extraction

- Hierarchical agglomerative clustering
  - Utilize the notion of context
    - Indicates the degree to which the ontological knowledge indicates that the concepts contained in two clusters are indeed semantically related.
- Overcomes most of the problems faced in the process
  - E.g. by ignoring clusters of low cardinality, we remove concepts that are misleading and should not be considered in the estimation of related topics.

User modeling

- **Dominant topics detection in a multimedia document is dual to detection of dominant topics in a list of multimedia documents in a user's usage history**
- A similar agglomerative clustering approach applies
  - extract user preferences based on usage history, when using a content based filtering
- Develop a vector based document similarity metric
  - each document represented in a vector space (like in IR)
  - major difference: the vocabulary used to form the vector contains *only higher level concepts*, i.e. topics.
  - Distinction between positive and negative user preferences
    - Different storage
    - Different handling
    - Weighted combination to form the final user profile

Discussion

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