Social Contexts and the Probabilistic Fusion and Ranking of Opinions: Towards a Social Semantics for the Semantic Web

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Introduction

- Web publishers are autonomous, possibly insincere actors
- Heterogeneous and controversial viewpoints on the (Semantic) Web are not just design problems, but inevitable and sometimes even useful in social environments
- Almost all traditional approaches to inconsistency and insincerity on the Web rely on some kind of filtering (by criteria such as trust or preferences)
- No sufficient means yet for
  - the formal representation of “the Web” itself, in terms of subjectivity, competing viewpoints, divergent opinions, intentionality, group knowledge…
  - the probabilistic/voting-based aggregation and representation of group beliefs

  = *Social Semantics*

- This work introduces a Description Context Logic for the representation of so-called certain and uncertain *Social Attitudes* (= public beliefs and intentions of groups and individuals)
Overview

- Issues
- Approach outline
- Features
- Social Attitudes
- Syntax (non-probabilistic)
- Semantics (non-probabilistic)
- P-SOC-OWL (probabilistic)
- Fusion and ranking of opinions
- Conclusion
Issues

• Semantic heterogeneity with impossible (or too expensive) alignment, subjectivity and irresolvable belief conflicts

• Inconsistent information simultaneously addressed to different parties and information published by/for specific social groups (e.g., in web blogs or intranets)

• Complexity caused by semantic heterogeneity

• Modeling of intentionality “behind” information

•OWL provides no suitable means for formalization of subjectivity

• RDF not suitable due to shallow / non-existent semantic wrt. subjectivity and sociality

• Traditional approaches to provenance only semi-formal or non-formal

• Modal logic usable (partially), cf. ISWC 2006 talk on Social Attitudes
Approach outline

- **Social Reification**: Subjective statements are lifted to the social level.

  E.g., “Sheep are red” → “Actor/Group s asserts: ‘Sheep are red’”

- Social Reification makes an inconsistent knowledge base or ontology consistent in case each of the sources provides consistent knowledge

- Technically: Contexts for individual and group beliefs and intentions

- Formal languages **SOC-OWL** (based on **SHOIN(D)** and C-OWL [Bouquet et al]) and **P-SOC-OWL** (based on C-OWL and P-SHOQ(D) [Giugno and Lukasiewicz])

- Modeling of social propositional attitudes (ostensible beliefs and intentions of individuals and groups)

- Private (mental) attitudes covered as a special case

- Optional: Differentiation of addressees (for the modeling of different “publics” or closed groups)

- Optional: Fusion operators for the aggregation of multiple opinions to a single group opinion
Features

• Simple and intuitive extensions of standard Description Logics / OWL-DL

• Consistent representation of inconsistencies acquired from dissenting sources (by means of “agree to disagree”)

• Allows for the modeling of both public and private beliefs and intentions

• Allows for the differentiation of several addresses

• Allows to aggregate multiple dissenting assertions via belief fusion operators

• BDI (standard framework for the reasoning about mental attitudes in agent research) is essentially a special case
Social Attitudes (1)

- SAs model individual and group attitudes regarding information (approval, denial, desire…) logically
- **Opinion**: The public (i.e., possibly insincere) attitude of an agent regarding the truth of a certain statement
- **Ostensible intention**: The public (i.e., possibly insincere) attitude of intending that a certain statement (or description, given DL) shall become true
- Triggered by implicit or explicit communication acts (e.g., web publishing, HTML links, web service assertions, discourses by blogging …)
- Allow, e.g., to model the “web personalities” of mentally opaque actors
- Multiple (possibly inconsistent) “web personalities” of the same actor are possible, even simultaneously
- Mental attitudes (i.e., personal, opaque beliefs and intentions) as a special case
Social Attitudes (2)

• Held by actors (individual or social group) towards a group of addressees
• Represented using Social Contexts (each indexed by attitude type □ source(-s) □ addressee(-s))
• Information ("passive" opinion): Information(a₁, a₂, φ)
• Public intention: PublicIntention(a₁, a₂, φ)
• Assertion ("active" opinion): Assertion(a₁, a₂, φ) = Information(a₁, a₂, φ) ∧ PublicIntention(a₁, a₂, Information(a₂, a₁, φ))
  (i.e., includes the intention to convince the addressees)
• Mental beliefs and intentions can be formulated as special cases:
  • Bel(a₁, φ) := Information(a₁, a₁, φ)
  • Int(a₁, φ) := PublicIntention(a₁, a₁, φ)
  • Internal group beliefs: Information(g, g, φ)
Syntax of **SOC-OWL**

(slightly simplified, cf. paper)

\[ C \rightarrow A \mid \neg C \mid C_1 \cap C_2 \mid \neg C \dagger C_2 \mid \exists R.C \mid \forall r.C \]
\[ \mid \geq nS \mid \leq nS \{a_1, ..., a_n\} \mid \geq nT \mid \leq nT \mid \exists T_1, ..., T_n.D \mid \forall T_1, ..., T_n.D \]

\[ D \rightarrow d \{c_1, ..., c_n\}. \]

**TBox and ABox:**

\( C_1 \sqsubseteq C_2, Trans(R), R \sqsubseteq S, T \sqsubseteq U, C(a), R(a, b), a = b, a \neq b, \)

”**SBox”:**

\[ \text{attitude} \]
\[ \text{source}_1, ..., \text{source}_n \rightarrow \text{addresse}_1, ..., \text{addresse}_n \sqsubseteq S \]

attitude: assertion, information, publicIntention

(+ bridge rules, socially contextualized concepts, individuals and roles, …)
Example

\[\text{ControversialPerson}(columbus)\]
\[\text{assertion}_{\text{tim},\text{tom} \rightarrow \text{tina}}(\neg \text{Hero})(columbus)\]
\[\text{assertion}_{\text{tina} \rightarrow \text{tim},\text{tom}}(\text{Hero})(columbus)\]
\[\text{assertion}_{\text{tim},\text{tom} \rightarrow \text{tina}}(\text{Exploiter})(columbus)\]

Note:

- Group beliefs do not constrain beliefs of group members
  (i.e., no common knowledge here, but cf. fusedInformation in paper Sect. 3.2)

- A certain source can hold mutually inconsistent opinions towards
different addressees

- Nesting of contextualized statements not allowed (unlike in “real” Context Logic):

\[\text{publicIntention}_{\text{tina}}(\text{information}_{\text{tim},\text{tom} \rightarrow \text{tina}}(\neg \text{Exploiter})(columbus))\]
Semantics of \textit{SOC-OWL}

(simplified, cf. paper & C-OWL)

\[ C_{id} = \text{any subset of } \Delta_{id} \text{ for } C \in C_{id} \]
\[ (C_1 \cap C_2)_{id} = C_1^{id} \cap C_2^{id} \text{ for } C_1, C_2 \in C_{id} \]
\[ (C_1 \cup C_2)_{id} = C_1^{id} \cup C_2^{id} \text{ for } C_1, C_2 \in C_{id} \]
\[ (-C)_{id} = \Delta_{id} \setminus C^{id} \text{ for } C \in C_{id} \]
\[ (\exists R. C)_{id} = \{ x \in \Delta^{id} : \exists y : (x, y) \in R^{id} \land y \in C^{id} \text{ for } C \in C_{id}, R \in R_{id} \}
\]
\[ (\forall R. C)_{id} = \{ x \in \Delta^{id} : \forall y : (x, y) \in R^{id} \rightarrow y \in C^{id} \text{ for } C \in C_{id}, R \in R_{id} \}
\]
\[ C^{id} = \text{any element of } \Delta^{id}, \text{ for } c \in c_{id} \]

Some meta-axioms:

- \text{assertion} \quad s_1, \ldots, s_n \rightarrow a_1, \ldots, a_m \varphi
  \rightarrow (\text{publicIntention} \quad (s_1, \ldots, s_n \rightarrow a_1, \ldots, a_m \sqcup \text{assertion} \quad a_1, \ldots, a_m \rightarrow s_1, \ldots, s_n, e) = (\text{assertion} \quad s_1, \ldots, s_n \rightarrow a_1, \ldots, a_m, e))

- \text{assertion} \quad s_1, \ldots, s_n \rightarrow a_1, \ldots, a_m \varphi \rightarrow \text{information} \quad s_1, \ldots, s_n \rightarrow a_1, \ldots, a_m \varphi

- Mutual consistency of all statements within a specific context

- [...]
SOC-OWL, plus contextualized statements with optional *probability intervals* for SBoxes:

\[ [p_l, p_u] \text{attitude}_{source_1, \ldots, source_n} \rightarrow \text{addresse}_1, \ldots, \text{addresse}_n \]

Interpretations extended with subjective probability functions \( \mu_{id} \) (cf. P-SHOQ(D)) for each context id:

\[ PI = \{(PI_{id}, \mu_{id}) : id \in Id\} \]

Examples:

\[ [0.5, 0.8]: \text{assertion}_{tim, tom} \rightarrow \text{tina} \text{Exploiter}(columbus) \]

\[ 0.9: \text{assertion}_{tim} \text{Hero}(columbus) \]

\[ 0.7: \text{assertion}_{tina} \text{Hero}(columbus) \]

...plus additional context type for aggregation: *fusedInformation*
Fusion and ranking of opinions (1)

Two approaches to derive social group opinions from other opinions:

\((\bigwedge_{s_i \in \{s_1, \ldots, s_n\}} (Pr_{\text{information}}_{s_i \rightarrow \text{addressees}} \models \varphi[p_i, p_i])) \rightarrow (Pr_{\text{information}}_{s_1, \ldots, s_n \rightarrow \text{addressees}} \models \varphi[p, p])\)

with pooling result \(p = \text{pool}^{\text{poolingType}}((p_1, \ldots, p_n), \text{priorKnowledge})\)

Problem: Possible inconsistencies in case freely defined group opinions exist in the KB/ontology.

Therefore:

\((\bigwedge_{s_i \in \{s_1, \ldots, s_n\}} (Pr_{\text{information}}_{s_i \rightarrow \text{addressees}} \models \varphi[p_i, p_i])) \rightarrow (Pr_{\text{fusedInformation}}_{s_1, \ldots, s_n \rightarrow \text{addressees}} \models \varphi[p, p])\)
Fusion and ranking of opinions (2)

Standard pooling operators:

Averaging:

\[ \text{pool}^{avg}((p_1, \ldots, p_n), \emptyset) = \frac{\sum p_i}{n} \]

Linear pooling with weights (e.g., to consider trust degrees or social power):

\[ \text{pool}^{LinOP}((p_1, \ldots, p_n), (\text{weight}_1, \ldots, \text{weight}_n)) = \sum \text{weight}_i p_i, \]

with \( \sum_{\text{weight}_i} = 1 \)

Logarithmic pooling:

\[ \text{pool}^{LogOP}((p_1, \ldots, p_n), (\text{weight}_1, \ldots, \text{weight}_n)) = \kappa \prod_{i=1}^{n} p_i^{\text{weight}_i} \]
Fusion and ranking of opinions (3)

Example using  \( \text{pool}^{avg}((p_1, \ldots, p_n), \emptyset) = \sum_{n} p_i \)

\([0.5, 0.8]: \text{assertion}_{\text{tim}, \text{tom} \rightarrow \text{tina}} \text{Exploiter(columbus)} \)

\(0.9: \text{assertion}_{\text{tim}} \text{Hero(columbus)}\)

\( \vdash 0.8: \text{assertion}_{\text{tina}, \text{tim}} \text{Hero(columbus)}\)

Induced rankings:

\(0.8: \text{information}_{\text{voters}} \text{innerStatement}_1 \) (highest social rating)

\([0.5, 0.8]: \text{information}_{\text{voters}} \text{innerStatement}_2\)

\(0.2: \text{information}_{\text{voters}} \text{innerStatement}_3 \) (lowest social rating)
Conclusion

• Presented a context-based Semantic Web language for the formal modeling of the “social dimension” of the Web and the Semantic Web

• Related developments:
  • FOL/dynamic logics for opinions and other social attitudes (cf. e.g. ECAI 2006)
  • Alternative DL-based approach using modal logic instead of contexts (cf. ISWC 2006 paper on Social Attitudes)
  • Further works: http://www.openontology.info

• Future work:
  • Issues:
    • Nested contexts
    • Open domains of actors (sources and addressees)
  • Implementation of a reasoner
  • Identification of emergent groups (knowledge communities) on the Web
Thank you very much for your attention!