KNOWLEDGE REPRESENTATION AND REASONING@UNL

João Leite

Who are we?


Alfredo Gabaldon


Carlos Damásio


João Leite


João Martins


João Moura


João Moura Pires


José Alferes


Marco Alberti


Martin Slota


Matthias Knorr


Nuno Datia


Ricardo Gonçalves


Ricardo Silva


Sofia Gomes

What we have been working on

Answer-Set Programming

- Extensions (Languages, Semantics and Tools)
  - Revisions and Updates
  - Evolution
  - Preferences
  - Abduction
  - Many-valued semantics
- Applications

Semantic Web

- Heterogeneous Knowledge (Languages, Semantics and Tools)
  - Combine Rules and Ontologies
  - Updates
  - Integration with Reactive Languages
  - Modular Rule Bases
- Applications

Dynamical Systems

- Multi-Agent Systems
  - Specification
  - Verification (Design time and run time)
  - Activity recognition
  - Social laws
- Social Networks
  - Argumentation Theory

In more detail…

- Hybrid Knowledge Bases
- Answer-Set Programming Updates
- Social Abstract Argumentation

Hybrid Knowledge Bases

M. Knorr, J. J. Alferes and P. Hitzler, Local closed world reasoning with description logics under the well-founded semantics. In Artificial Intelligence 175(9-10): 1528-1554, 2011

Combining rules and ontologies

- The goal was to represent knowledge using a combination of rules and ontologies.
- Full integration
  - The vocabularies are the same
  - Predicates can be defined either using rules or using DL
  - The base assumptions of DL and of non-monotonic rules are quite different. Tightly mixing them is not easy
    - Decidability
    - OWA vs CWA

Interaction without full integration

- Other approaches combine (DL) ontologies, with (nonmonotonic) rules without fully integrating them:
  - Tight semantic integration
    - Separate rule and ontology predicates
    - Adapt existing semantics for rules in ontology layer
    - Adopted e.g. in DL+log [Rosati 2006] and the Semantic Web proposal SWRL [w3c proposal 2005]
  - Semantic separation
    - Deal with the ontology as an external oracle
    - Adopted e.g. in dl-Programs [Eiter et al. 2005]

Full Integration

- Approaches to the problem of full integration of DL and (nonmonotonic) rules:
  - Open Answer Sets [Heymans et al. 2004]
  - Equilibrium Logics [Pearce et al. 2006]
  - Hybrid MKNF [Motik and Rosati 2007]
    - Based on interpreting rules as auto-epistemic formulas
    - DL part is added as a FOL theory, together with the rules
  - Well founded Hybrid MKNF [Knorr et al. 2008]
    - Good computational complexity

Answer-Set Programming Updates

M. Slota and J. Leite, On Semantic Update Operators for Answer-Set Programs, in ECAI 2010.

Logic Programs

- Syntax:
  - a set of propositional atoms L
  - a logic program is a set of rules of the form

$$p_1;\dots;p_m;\sim q_1;\dots;\sim q_n \leftarrow r_1,\dots,r_o, \sim s_1,\dots, \sim s_p$$

- Semantics:
  - an interpretation is any set of atoms
  - a model is an interpretation that does not violate any rules
  - answer sets are a widely accepted semantics with many applications and efficient implementations

$$P = \{\ p \leftarrow \sim q \qquad q \leftarrow \sim p \qquad r \leftarrow q, \sim s\ \}$$

$$M1 = \{\ p\ \} \qquad M2 = \{\ q, r\ \}$$

Belief Change

- Change operations on monotonic logics have been studied extensively in the area of belief change.
  - rationality postulates for operations play a central role
  - constructive operator definitions correspond to sets of postulates
- two different belief change operations have been distinguished [Katsuno and Mendelzon1991]:
  - Revision
    - recording newly acquired information about a static world
    - characterized by AGM postulates and their descendants
  - Update
    - recording changes in a dynamic world
    - characterized by KM postulates for update

Belief Change and Rule Evolution

- directly applying the postulates and constructions from belief change to answer set programs leads to a number of serious problems [Alferes et al. 1998, Eiter et al. 2002]
  - ambiguity of the postulates
  - some postulates are difficult to formulate for logic programs
  - leads to very counterintuitive results
- led to more syntactic approaches based on different principles
- reconciliation of belief change with rule evolution is still a very interesting open problem
  - a more general understanding of knowledge evolution
  - a semantic approach to rule evolution, focusing only on the meaning of a logic program and not on its syntactic representation

Belief Change and SE Models

- SE models [Turner2003]:
  - semantic characterisation of logic programs
  - richer structure – an SE interpretation X is a pair of ordinary interpretations I,J such that $I \subseteq J$
  - monotonic and more expressive than answer sets
  - characterize strong equivalence
- AGM revision on SE models [Delgrande et al. 2008]
- Our goal: Examine Katsuno and Mendelzon's update on SE models.

Belief Update

Postulates (KM 1) – (KM 8)

(KM 1) $\phi \diamond \psi \models \psi$.

(KM 2) If $\phi \models \psi$, then $\phi \diamond \psi \equiv \phi$.

(KM 3) If both ϕ and ψ are satisfiable, then $\phi \diamond \psi$ is satisfiable.

(KM 4) If $\phi_1 \equiv \phi_2$ and $\psi_1 \equiv \psi_2$, then $\phi_1 \diamond \psi_1 \equiv \phi_2 \diamond \psi_2$.

(KM 5) $(\phi \diamond \psi) \wedge \chi \models \phi \diamond (\psi \wedge \chi)$.

(KM 6) If $\phi \diamond \psi_1 \models \psi_2$ and $\phi \diamond \psi_2 \models \psi_1$, then $\phi \diamond \psi_1 \equiv \phi \diamond \psi_2$.

(KM 7) $(\phi \diamond \psi_1) \wedge (\phi \diamond \psi_2) \models \phi \diamond (\psi_1 \vee \psi_2)$ if ϕ is complete.

(KM 8) $(\phi_1 \vee \phi_2) \diamond \psi \equiv (\phi_1 \diamond \psi) \vee (\phi_2 \diamond \psi)$.

Belief Update

- Construction:
  - ω assigns a partial order $\leq_I^\omega$ to every interpretation I

$$[[\phi \circ \psi]] = \bigcup_{I \in [[\phi]]} \min\left([[\psi]], \leq_I^\omega\right) \qquad (1)$$

- Representation Theorem
  - A belief update operator $\circ$ satisfies conditions (KM1)–(KM8) if and only if there exists a faithful partial order assignment ω such that (1) is satisfied for all formulae ϕ and ψ
- Winslett's operator is obtained with

$$J \leq_I^\omega K \quad \mathit{iff} \quad (J \div I) \subseteq (K \div I)$$

SE Model Update

Postulates (PU 1) – (PU 8)

(PU 1) $\mathcal{P} \oplus \mathcal{Q} \models_s \mathcal{Q}$.

(PU 2) If $\mathcal{P} \models_s \mathcal{Q}$, then $\mathcal{P} \oplus \mathcal{Q} \equiv_s \mathcal{P}$.

(PU 3) If both $\mathcal{P}$ and $\mathcal{Q}$ are satisfiable, then $\mathcal{P} \oplus \mathcal{Q}$ is satisfiable.

(PU 4) If $\mathcal{P}_1 \equiv_s \mathcal{P}_2$ and $\mathcal{Q}_1 \equiv_s \mathcal{Q}_2$, then $\mathcal{P}_1 \oplus \mathcal{Q}_1 \equiv_s \mathcal{P}_2 \oplus \mathcal{Q}_2$.

(PU 5) $(\mathcal{P} \oplus \mathcal{Q}) \dot{\wedge} \mathcal{R} \models_s \mathcal{P} \oplus (\mathcal{Q} \dot{\wedge} \mathcal{R})$.

(PU 6) If $\mathcal{P} \oplus \mathcal{Q}_1 \models_s \mathcal{Q}_2$ and $\mathcal{P} \oplus \mathcal{Q}_2 \models_s \mathcal{Q}_1$, then $\mathcal{P} \oplus \mathcal{Q}_1 \equiv_s \mathcal{P} \oplus \mathcal{Q}_2$.

(PU 7) $(\mathcal{P} \oplus \mathcal{Q}_1) \dot{\wedge} (\mathcal{P} \oplus \mathcal{Q}_2) \models_s \mathcal{P} \oplus (\mathcal{Q}_1 \dot{\vee} \mathcal{Q}_2)$ if $\mathcal{P}$ is basic.

(PU 8) $(\mathcal{P}_1 \dot{\vee} \mathcal{P}_2) \oplus \mathcal{Q} \equiv_s (\mathcal{P}_1 \oplus \mathcal{Q}) \dot{\vee} (\mathcal{P}_2 \oplus \mathcal{Q})$.

SE Model Update

- Construction:
  - ω assigns a partial order $\leq_X^\omega$ to every interpretation X

$$[[P \oplus Q]]^{SE} = \bigcup_{X \in [[P]]^{SE}} \min\left([[Q]]^{SE}, \leq_X^\omega\right) \qquad (2)$$

- Representation Theorem
  - A program update operator $\oplus$ satisfies conditions (KM1)–(KM8) if and only if there exists a faithful and organised partial order assignment ω such that (1) is satisfied for all programs P and Q.
- Instance operator $\langle I_1, J_1 \rangle \leq_{\langle K,L \rangle}^\omega \langle I_2, J_2 \rangle \quad iff$

1. $(J_1 \div L) \subseteq (J_2 \div L)$
2. $If\ (J_1 \div L) = (J_2 \div L),\ then\ (I_1 \div K) \setminus \Delta \subseteq (I_2 \div K) \setminus \Delta$

   $where\ \Delta = J_1 \div L$

SE Model Update

Great!

But…

Static Support

- Literal Support
  - Let P be a program, L a literal and I an interpretation. We say that P supports L in I if and only if there is some rule $r \in P$ such that $L \in H(r)$ and $I \models B(r)$.
- Supported Semantics
  - A Logic Programming semantics SEM is supported if for each model I of a program P under SEM the following condition is satisfied:

    Every atom $p \in I$ is supported by P in I.

Dynamic Support

- Support-respecting program update operator
  - We say a program update operator $\circ$ respects support if the following condition is satisfied for all programs P, Q, and all answer sets I of $P \oplus Q$:

    Every atom $p \in I$ is supported by $P \cup Q$.

Fact Update

- Fact update-respecting program update operator
  - We say a program update operator respects fact update if for all consistent sets of facts P, Q, the unique answer-set of P $\oplus$ Q is the interpretation

$$\{p \mid (p.) \in P \cup Q \wedge (\sim p.) \notin Q\}$$

Problem with SE Model Update

- Theorem A program update operator that satisfies (PU4) either does not respect support or it does not respect fact update.
- Proof
  - Let $\oplus$ be a program update operator that satisfies PU4 and let:

    P1: p. q.   P2: $p \leftarrow q$. q.   Q: ~q.

  - Since $P_1 \equiv_S P_2$, by (PU4) we have that $P_1 \oplus Q \equiv_S P_2 \oplus Q$. Consequently, $P_1 \oplus Q$ has the same answer sets as $P_2 \oplus Q$.
  - Since $\oplus$ respects fact update, then $P_1 \oplus Q$ has the unique answer set {p}.
  - But then {p} is an answer set of $P_2 \oplus Q$ in which p is unsupported by $P_2 \cup Q$.
  - Hence $\oplus$ does not respect support.

About Answer-Set Program Updates

- Katsuno and Mendelzon's update for logic programs under the SE models semantics works similarly as for classical logic
- BUT reasonable update operators do not respect support ways out:
  - abandon the classical postulates and constructions
  - use existing approaches with a syntactic flavour
  - find a more expressive characterisation of logic programs
    - M. Slota and J. Leite, Robust Equivalence Models for Semantic Updates of Answer-Set Programs. Forthcoming at KR'12.

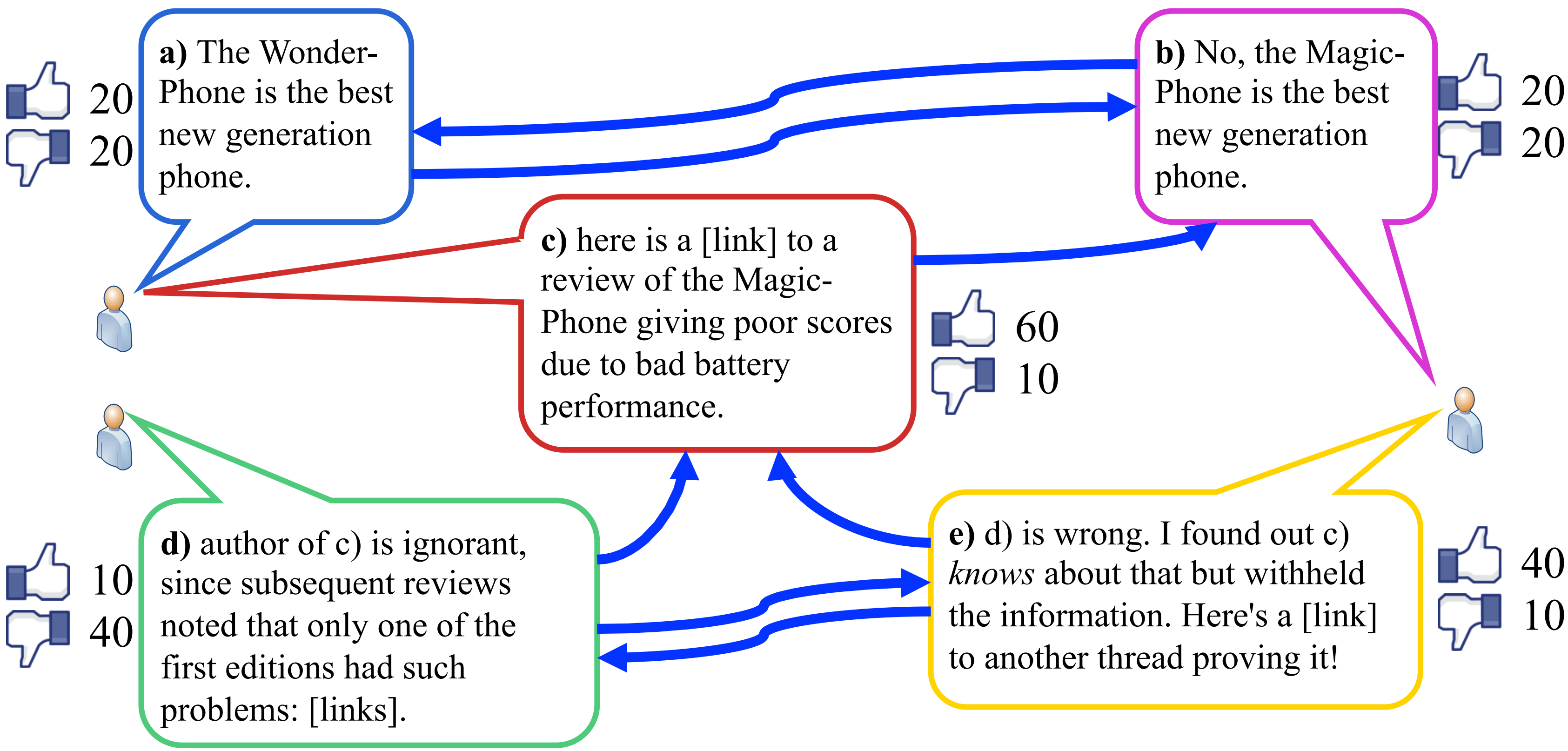
Social Abstract Argumentation

J. Leite and J. Martins, Social Abstract Argumentation, in IJCAI 2011.

Social Abstract Argumentation

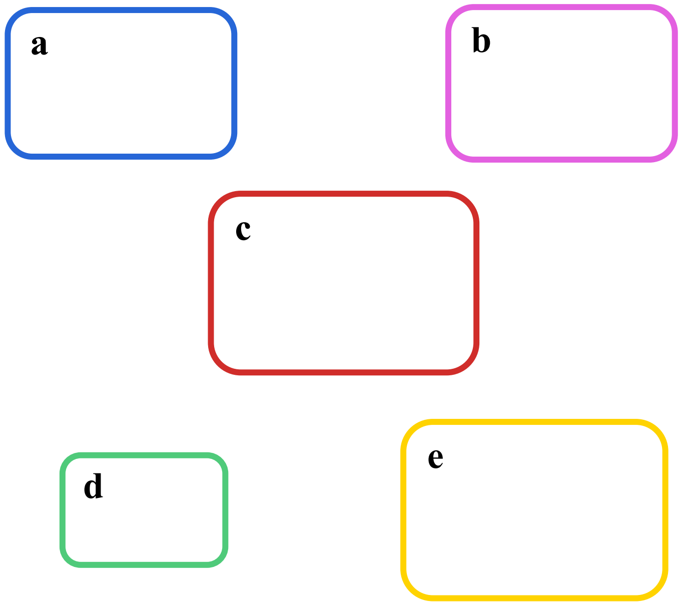
- Interactions in Social Networks are unstructured, often chaotic.
- Prevents a fulfilling experience for those seeking deeper interactions and not just increasing their number of
- Our Vision
  - A self-managing online debating system capable of accommodating two archetypal levels of participation:
    - experts/enthusiasts - who specify arguments and the attacks between arguments.
    - observers/random browsers - will vote on individual arguments, and on the specified attacks.
    - autonomously maintaining a formal outcome to debates by assigning a strength to each argument based on the structure of the argumentation graph and the votes.

Social Abstract Argumentation

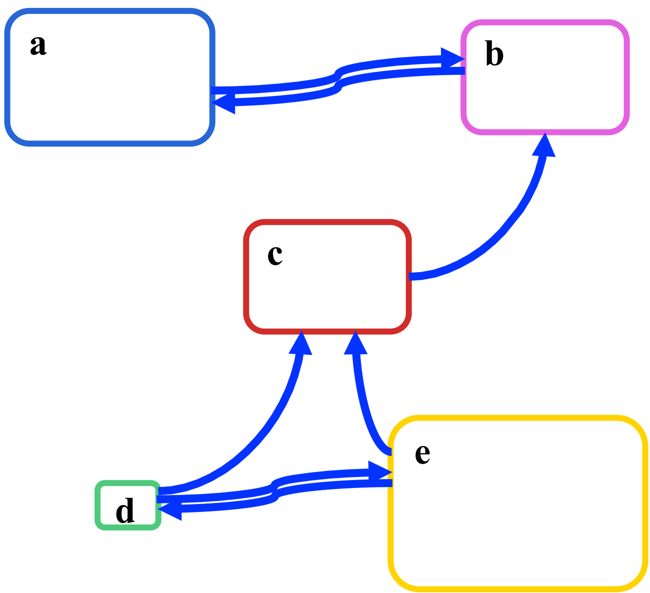


Social Abstract Argumentation

- Social Support
  - votes only



- Social Strength
  - votes and attacks



Social Abstract Argumentation

- Desirable Properties
  - Must have a model for every debate.
  - Should have only one model for each debate.
  - Argument Social Strength should go beyond Accept/ Defeat.
  - Every vote should count.
  - Social Strength should be limited by popular opinion.
  - System should evolve smoothly.

Social Abstract Argumentation

- Social Abstract Argumentation Framework extends Dung's Abstract Argumentation Framework with votes on arguments.
- Proposed semantic framework.
  - Determines the Social Strength of arguments.
  - Parametric on general operators to determine the combined strength of joint attacks by arguments with different social strength (directly given by the votes – social support – and indirectly taken away by other arguments).
  - Instantiations with specific operators enjoy many desirable properties.

What we are currently working on

Hybrid Languages for the Semantic Web

- Goals
  - Deal with inconsistent knowledge
  - Deal with dynamic knowledge
  - Deal with active systems
- To Do
  - Theoretical work
  - Implementation of reasoning tools
  - Integration with Protégé Ontology Editor (plugins)

Argumentation Theory

- Goals
  - Incorporate Argumentation Theory in Social Networks
  - Investigate Argumentation Strategies
- To Do
  - Theoretical Work
  - Implementation of tools for Social Web argumentation
  - Simulation

Norms in Multi-Agent Systems

- Goals
  - Deal with various kinds of norms in MAS in a principled way
    - Obligations, Power, Time, Actions, …
- To Do
  - Theoretical work
  - Implementation of reasoning tools
  - Integration with Agent Oriented Programming Languages

Answer-Set Programming

- Updates
- Many-valued Semantics
- Applications
- Debugging

KRR@UNL

- Weekly Group Meetings and Seminars
- Weekly Open House
- Several Ongoing Research Projects with opportunities for
  - MSc Projects
  - MSc Theses
  - PhD Theses (some with grants)
- Ask me for more information (jleite@fct.unl.pt)

The Members


You!


Alfredo Gabaldon


Carlos Damásio


João Leite


João Martins


João Moura


João Moura Pires


José Alferes


Marco Alberti


Martin Slota


Matthias Knorr


Nuno Datia


Ricardo Gonçalves


Ricardo Silva


Sofia Gomes

Open House @ UNL

Open House @ UNL

Open House @ UNL

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