Who are we?
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
Logic Programs

- **Syntax:**
  - a set of propositional atoms $L$
  - a logic program is a set of rules of the form
    \[ p_1; \ldots ; p_m; \neg q_1; \ldots ; \neg q_n \leftarrow r_1, \ldots , r_o, \neg s_1, \ldots , \neg s_p \]

- **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

\[
P = \{ p \leftarrow \neg q \quad q \leftarrow \neg p \quad r \leftarrow q, \neg s \}\]
\[
M_1 = \{ p \} \quad M_2 = \{ q, r \}
\]
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 Mendelzon 1991]:
  - 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** [Turner 2003]:
  - 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) \( \phi \circ \psi \models \psi \).

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

(KM 3) If both \( \phi \) and \( \psi \) are satisfiable, then \( \phi \circ \psi \) is satisfiable.

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

(KM 5) \( (\phi \circ \psi) \land \chi \models \phi \circ (\psi \land \chi) \).

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

(KM 7) \( (\phi \circ \psi_1) \land (\phi \circ \psi_2) \models \phi \circ (\psi_1 \lor \psi_2) \) if \( \phi \) is complete.

(KM 8) \( (\phi_1 \lor \phi_2) \circ \psi \equiv (\phi_1 \circ \psi) \lor (\phi_2 \circ \psi) \).
Belief Update

- **Construction:**
  - \( \omega \) assigns a partial order \( \leq^\omega_I \) to every interpretation \( I \)

\[
[[\phi \circ \psi]] = \bigcup_{I \in [[\phi]]} \min \left( [[\psi]], \leq^\omega_I \right)
\]  

- **Representation Theorem**
  - A belief update operator \( \circ \) satisfies conditions (KM1)–(KM8) if and only if there exists a faithful partial order assignment \( \omega \) such that (1) is satisfied for all formulae \( \phi \) and \( \psi \)

- **Winslett’s operator is obtained with**
  
\[
J \leq^\omega_I K \quad \text{iff} \quad (J \div I) \subseteq (K \div I)
\]
SE Model Update

Postulates (PU 1) – (PU 8)

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

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

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

(PU 4) If \( \mathcal{P}_1 \equiv_s \mathcal{P}_2 \) and \( Q_1 \equiv_s Q_2 \), then \( \mathcal{P}_1 \oplus Q_1 \equiv_s \mathcal{P}_2 \oplus Q_2 \).

(PU 5) \( (\mathcal{P} \oplus Q) \land \mathcal{R} \models_s \mathcal{P} \oplus (Q \land \mathcal{R}) \).

(PU 6) If \( \mathcal{P} \oplus Q_1 \models_s Q_2 \) and \( \mathcal{P} \oplus Q_2 \models_s Q_1 \), then \( \mathcal{P} \oplus Q_1 \equiv_s \mathcal{P} \oplus Q_2 \).

(PU 7) \( (\mathcal{P} \oplus Q_1) \land (\mathcal{P} \oplus Q_2) \models_s \mathcal{P} \oplus (Q_1 \lor Q_2) \) if \( \mathcal{P} \) is basic.

(PU 8) \( (\mathcal{P}_1 \lor \mathcal{P}_2) \oplus Q \equiv_s (\mathcal{P}_1 \oplus Q) \lor (\mathcal{P}_2 \oplus Q) \).
SE Model Update

- **Construction:**
  - \( \omega \) assigns a partial order \( \leq_{X}^{\omega} \) to every interpretation \( X \)

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

  \((2)\)

- **Representation Theorem**
  - A program update operator \( \oplus \) satisfies conditions (KM1)–(KM8) if and only if there exists a faithful and organised partial order assignment \( \omega \) such that (1) is satisfied for all programs \( P \) and \( Q \).

- **Instance operator**
  \( \langle I_1, J_1 \rangle \leq_{\langle K, L \rangle}^{\omega} \langle I_2, J_2 \rangle \) 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-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

$$\{ p | (p.) \in P \cup Q \land (\neg p.) \notin Q \}$$
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:
    
    - $P_1: \ p$.
    - $P_2: \ p \leftarrow q$.
    - $Q: \ \neg q$.
    
    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.
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

Social Abstract Argumentation

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 likes.
- 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.
a) The Wonder-Phone is the best new generation phone.

c) here is a [link] to a review of the Magic-Phone giving poor scores due to bad battery performance.

d) author of c) is ignorant, since subsequent reviews noted that only one of the first editions had such problems: [links].

e) d) is wrong. I found out c) knows about that but withheld the information. Here's a [link] to another thread proving it!

b) No, the Magic-Phone is the best new generation phone.
Social Abstract Argumentation

- **Social Support**
  - votes only

- **Social Support**
  - votes only

- **Social Strength**
  - votes and attacks

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  - votes and attacks
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
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)
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