Research profile

The role of logic and declarative languages in artificial intelligence is the central focus of research in the DTAI lab. Research on this theme started in the department with the PhD work of Maurice Bruynooghe (1979), and rapidly gained international recognition with the booming interest in logic programming and computational logic during the eighties. The field (and the lab) blossomed and the range of activities widened as the importance of logic became pertinent in such areas as programming languages, knowledge representation, constraint programming, machine learning, data mining, and reasoning about uncertainty (using probabilistic logics). The lab now has about 60 researchers and explores all these research trends.

Keywords

declarative programming languages • logic programming • Prolog • constraint programming • program analysis • abstract interpretation • constraint handling rules • program transformation • artificial intelligence • knowledge representation • non-monotonic reasoning • inductive definitions • abduction • induction • machine learning • knowledge discovery • data mining • statistical relational learning • computational biology • predictive personalized medicine • web mining • probabilistic reasoning

Research Themes

DECLARATIVE TECHNIQUES FOR ANALYSIS AND IMPLEMENTATION OF PROGRAMMING LANGUAGES AND SYSTEMS

Declarative programming languages aim at making software development less labour intensive and error-prone. They offer high level programming constructs that allow the programmer to focus more on the "what" and less on the "how" of the goal to be achieved. Typical representatives are functional and logic programming languages. They relieve the programmer from low-level details such as memory management and provide a simple and clear semantics that is an excellent basis for automatic program analysis. The latter is a must to realize implementations of declarative languages that can compete in performance with imperative languages.
Research items
- Implementation technology for logic programming systems: memory management, constraints, support for inductive and probabilistic logic programming, and analysis based optimisations.
- Program analysis (termination) and transformation.
- Constraint Handling Rules (CHR): a rule-based language at the intersection of constraint logic programming and term rewriting.

KNOWLEDGE TECHNOLOGY
Knowledge technology differs from software technology in its focus on the development of information systems in which knowledge is the central component. Typically, the target applications for this technology are based on high-level specifications of complex knowledge and use automated problem solving techniques for performing particular tasks. The development of formal (logic) languages for representing domain knowledge and of suitable inference mechanisms is the cornerstones of our research in knowledge technology.

Research items
- Knowledge representation languages: FO(ID), an extension of first order logic with inductive (recursive) definitions, logics for modelling probabilistic causal processes, logics for reasoning on intensional objects.
- Theoretical and computational analysis of these languages (semantics, expressiveness, inference algorithms, decidability and complexity).
- Development of systems to autonomously solve a variety of computational tasks on the basis of a knowledge base and diverse forms of inference.

MACHINE LEARNING AND DATA MINING
Machine learning and data mining employ artificial intelligence techniques for analysing large and complex data sets. They are often based on inductive reasoning, which is the process whereby one generalizes specific observations into general hypotheses. These hypotheses can then be used to make predictions and also to obtain insight into the underlying domain. The DTAI group is well known for its work on using logic for machine learning and data mining (known as inductive logic programming). It has focused on analyzing structured data (for instance, in computational chemistry), on the use of domain knowledge in the induction process, and on declarative methods (for instance, constraints) in data mining. It is interested in theory, methods, and applications.

Research items
- Probabilistic Logic Learning (or statistical relational learning), an emerging subfield at the intersection of knowledge representation, reasoning about uncertainty and machine learning.
- The integration of constraint programming and data mining as well as constraint-based data mining and inductive databases.
- Theoretical foundations of graph mining.
- Applications in computational biology, natural language processing, computer vision, mechatronics and robotics.
- Data Stream Mining.
- Supervised Learning.
- Unsupervised and semi-supervised learning.
- Causal models.
- Web mining including the analysis of different types of Web data, of different genres of Web information, and of privacy and information literacy.

Collaborations
National: Universiteit Hasselt, Ghent University, University of Antwerp, Vrije Universiteit Brussel, Univ. Libre de Bruxelles, Univ. de Mons-Hainaut, Alcatel, Flanders Mechatronics Technology Center, IMEC, Xtendit Solutions, Agfa Healthcare.


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