

# Livio Robaldo

## Curriculum Vitae et Studiorum

### Personal Information

<i>Name Surname</i>	<b>Livio Robaldo</b>
<i>Date of birth</i>	<b>23/06/1979</b>
<i>Contacts</i>	<b>livio.robaldo@uni.lu</b>
<i>Current work position</i>	<b>Post-doc Researcher at the University of Luxembourg.</b>

### Track record

Livio Robaldo is a **Post-doc Researcher** at the Interdisciplinary Centre for Security, Reliability and Trust (SnT) of the University of Luxembourg, supported by the project “DAPRECO - DATA Protection REGulation COMPLIance”, which has been evaluated and retained for funding by the **Fonds National de la Recherche (FNR)**. DAPRECO is **the single senior CORE project** proposed by SnT in 2016 that has been retained for funding, **out of 18 submitted ones**.

In 2017, he participated in the writing of the **Marie Skłodowska-Curie Innovative Training Networks (ITN)** project “LAST-JD RIoE - Rights of the Internet of Everything”, which has been evaluated and retained for funding under the call H2020-MSCA-ITN-2017, with the **overall score of 94.80%**. Livio Robaldo is currently the principal responsible of the LAST-JD International Doctorate in “Law, Science, and Technology” for the University of Luxembourg.

In 2015, he coordinated the writing of the **Marie Skłodowska-Curie Research and Innovation Staff Exchange (RISE)** project “MIREL - MIning and REasoning with Legal texts”, which has been evaluated and retained for funding under the call H2020-MSCA-RISE-2015, with the **overall score of 97.20%**. In the context of MIREL, Livio Robaldo was an **official Visiting Scholar at Stanford University** from October to December 2017.

In 2015, he won a **Marie Skłodowska-Curie Individual fellowship** under the call H2020-MSCA-IF-2014\_ST, on the project “ProLeMAS: PROcessing LEgal language in normative Multi-Agent Systems”, with the **overall score of 96.40%**.

In 2014, he won the **Working Capital Accelerator 2014**, a Telecom Italia grant to support new startups and innovative research projects. The selection was highly competitive: **only 40 projects out of about 1,300 submitted ones were selected**. Each selected project was granted 25,000 euros, VAT excluded, from Telecom Italia.

Since 2004, Livio Robaldo participated also in **18 financed research projects** and he had an active role in the **writing of 11 of them**. He also participated on a voluntary basis in other research projects, among which the **Penn Discourse Treebank** and **Anawiki**, which are respectively hosted at the University of Pennsylvania and the University of Essex.

In February 2014, Livio Robaldo became a partner of **Nomotika SRL**, a spin-off of the University of Turin, upon invitation of the founders, due to their interests in his developed tools and resources. In particular, Livio Robaldo was **responsible of the NLP Toolkit** in the project **EUCases**, an European research project supported by 7th Framework Programme funding.

Livio Robaldo earned a **MSc** and a **Ph.D.** in **Computer Science** from the University of Turin.

Afterwards, he spent **5+2 months** as a **visiting researcher at the University of Pennsylvania**, Philadelphia (USA), in 2007 and 2009. In 2015 and 2016, he visited the private company **APIS Hristovich EOOD** in Sofia for **6 months** in the context of the project ProLeMAS, while from October to December 2017 he was an **official Visiting Scholar at Stanford University**, Palo Alto (USA), in the context of the project MIREL.

The **networking activity** of Livio Robaldo led him to build a solid net of contacts with several researchers he met in conferences and workshops. Livio Robaldo also coauthored papers with some of them, e.g., Jerry Hobbs (University of Southern California), Eleni Miltsakaki and Aravind Joshi (University of Pennsylvania), Massimo Poesio (University of Essex), Jakub Szymanik (University of Amsterdam), and Dov Gabbay (King's college, London).

The current research activity of Livio Robaldo is centered on **Legal Informatics**, specifically to the application of **Natural Language Semantics** and **Natural Language Processing** to the legal domain, in the context of the projects ProLeMAS, MIREL, and DAPRECO. His main scientific result in Legal Informatics is **reified Input/Output logic**, a formalism for representing norms in natural language developed in the project ProLeMAS and currently used in the projects MIREL and DAPRECO. His experience in Natural Language Semantics and Natural Language Processing has been built in the context of other research projects he worked in the past, among which it is worth mentioning **Eunomos**, an advanced legal document management system based on legislative XML representation of laws; **Dependency Tree Semantics**, an underspecified semantic formalism for handling Independent Set readings in NL; the **Turin University Linguistic Environment (TULE)**, a morpho-syntactic analyzer that associate natural language text with dependency trees; the **Penn Discourse Treebank**, a corpus devoted to the annotation of discourse connectives, hosted at the University of Pennsylvania; **Anawiki**, a project of the University of Essex aiming at developing tools to allow and encourage large numbers of volunteers over the Web to collaborate in the creation of semantically annotated corpora; **OpinionMining-ML**, an XML formalism for tagging users' opinions with respect to products and services.

The results of the research activity of Livio Robaldo have been published in **85 locations** (journals, conferences, workshops, and technical reports), among which **sixteen journal papers**. He is the **single author of four journal papers** and several conference papers. Scopus reports **573 citations** of his papers.

He presented his research in several conferences, also as an **invited speaker at IUI2013**. He was a reviewer of the **Artificial Intelligence** journal, the **Journal of Logic, Language, and Information**, the **Journal of Semantics**, and several conferences (ECAI, CogSci, etc.).

His teaching activity includes **923 hours of teaching** in the roles of **Lecturer, Teaching Assistant**, and **External Collaborator** for undergraduates, high school students, and companies. He co-supervised the thesis of five Ph.D. students and three master&bachelor students. He is the principal responsible for the University of Luxembourg of the **LAST-JD International Doctorate in Law Science and Technology** (<http://www.last-jd.eu>) and he follows several students by advising them in their research activity.

Further details may be found below in the respective sections.

## Education

Livio Robaldo earned a **MSc in Computer Science** from the Department of Computer Science of the University of Turin, on July 2003, with the final mark of **110 cum laude and mention for the exceptional curriculum**. On February 2007, he earned, from the same department, a **Ph.D in Computer Science**, by defending a thesis titled **Dependency Tree Semantics**.

After the defence of the Ph.D. thesis, Livio Robaldo was a visiting researcher at the **University of Pennsylvania (UPenn)** (Philadelphia, USA) from February 2007 to June 2007, and again two years later, from June 2009 to July 2009. In 2015 and 2016, he visited the Bulgarian company **APIS Hristovich EOOD** in Sofia, in the context of the project ProLeMAS, for six months in total. In

2017, he was an **official visiting scholar at Stanford University** for three months. He visited, for shorter periods, other universities in Europe and in the United States.

Furthermore, Livio Robaldo attended summer schools and obtained awards related to his research activity. The full list of his education experiences is reported below:

- Mar 2017 - May 2017*    **Visiting scholar at Stanford University (USA)**, in the context of the project MIREL. Scientific referent: Prof. Cleo Condoravdi.
- Oct 2017 - Dec 2017*    **Visiting researcher at APIS Hristovich EOOD**, Bulgaria, in the context of the project ProLeMAS.
- Sep 2015 - Nov 2015*    **Visiting researcher at APIS Hristovich EOOD**, Bulgaria, in the context of the project ProLeMAS.
- Mar 2015*    **NorMAS 2015 School**: ‘Normative Multi-Agent Systems’, Dagstuhl Seminar at Leibniz Center for Informatics, Dagstuhl, Germany.
- Sep 2014 - Oct 2014*    **WCAP 2014 Program**: ‘Working Capital Accelerator 2014 Program’, attendance of the **two-months intensive seminar series** devoted to start-up foundation, pitch preparation, business and marketing analysis, etc., organized in Milan by Telecom Italia for WCAP 2014 winners.
- Sep 2014*    **LEX 2015 School**: ‘Akoma Ntoso DEV Workshop’, collocated at LEX2014 summerschool, Ravenna, Italy.
- Jun 2009 – Jul 2009*    **Visiting researcher at Penn University**, Philadelphia, USA. Scientific supervisors: Prof. Eleni Miltsakaki, Prof. Aravind Joshi.
- Feb 2007 – Jun 2007*    **Visiting researcher at Penn University**, Philadelphia, USA. Scientific supervisor: Prof. Maribel Romero.
- Feb 2007*    **Ph.D. in Computer Science (XIX cycle)**, Department of Computer Science, University of Turin.
- Jul 2005*    **ESSLLI 2005 School**: 17th European Summer School in Logic, Language and Information, Edinburgh.
- Jul 2004*    **International Doctoral School “Chambery-Torino”**: International Doctoral School in Theoretical Computer Science and Semantic Web, Aussois (Savoie-France).
- Apr 2004*    **BISS 2004 School**: Bertinoro International Spring School 2004, Bertinoro, Italy.
- Sep 2004*    Winner of **premio Optime**, Confindustria award given to the best graduates of the University and Polytechnic of Turin, for the Academic year 2003-2004.
- Jul 2003*    **MSc in Computer Science**, with the final mark of **110 cum laude and mention for the exceptional curriculum**, Department of Computer Science, University of Turin.
- Jul 1998*    **Technical-Industrial Diploma in Computer Science**, with the final mark of **54/60**, ITIS “A. Avogadro”, Turin.

## Ph.D Thesis:

<i>Title:</i>	<b>Dependency Tree Semantics</b>
<i>Supervisor:</i>	Prof. Leonardo Lesmo
<i>External reviewers:</i>	Prof. Maribel Romero (Penn University, Philadelphia, USA) Prof. Johan Bos (Università “La Sapienza”, Roma, Italy)
<i>Description:</i>	Dependency Tree Semantics (DTS) is a novel semantic formalism for underspecifying the scope of NL quantifiers. The key idea is to achieve underspecification via Skolem-like dependencies. DTS’s main advantage, with respect to its contemporary proposals, is the ability of representing Independent Set readings, i.e. readings where multiple sets of entities are independent of one another.

## Work positions

Livio Robaldo is currently a **Post-doc Researcher** at the Interdisciplinary Centre for Security, Reliability and Trust of the University of Luxembourg. In the past, he worked in several other research projects, supported either by other fellowships or by private contracts.

Livio Robaldo’s working activity is of course intimately related to his scientific activity. For this reason, Livio Robaldo became a partner in **Nomotika SRL**, a spin-off of the University of Turin. As explained in the next section, his role in Nomotika is contributing to the technology transfer of the research developed in the Department of Computer Science into the business of the company.

<i>Jun 2017 - today</i>	<b>Postdoc fellowship</b> at the University of Luxemboug for the project “DAPRECO: DATA Protection REGulation COMPLIance”.
<i>Jun 2015 - May 2017</i>	<b>Marie Skłodowska-Curie Individual fellowship</b> for the project “ProLeMAS: PROcessing LEgal language in normative Multi-Agent Systems”.
<i>Oct 2013 - May 2015</i>	<b>Post-doctoral fellow</b> (Assegno di Ricerca) for the project “The role of visual imagery in lexical processing”, financed by the University of Turin and Compagnia di San Paolo.
<i>Oct 2012 - Sep 2013</i>	<b>Post-doctoral fellow</b> (Assegno di Ricerca) for the ‘LIS4ALL’ project, ‘Lingua Italiana dei Segni per l’Accesso su Larga scala ad informazioni Localizzate (EN: <i>Italian sign language for large-scale access to localised information</i> ), financed by Regione Piemonte.
<i>Jul 2012 - Sep 2012</i>	<b>Private project contract</b> with <b>SSB Progetti SRL</b> for the ‘ICT4LAW’ project, ‘ICT Converging on Law: Next Generation Services for Citizens, Enterprises, Public Administration and Policymakers’, financed by Regione Piemonte.
<i>Mar 2012 - Jun 2012</i>	<b>Private project contract</b> with <b>Virtual Reality &amp; Multi Media Park</b> for the ‘ATLAS’ project, ‘Automatic Translation into Sign Languages’, financed by Regione Piemonte.

- Mar 2008 - Feb 2012*      **Post-doctoral fellow** (IT: Assegno di Ricerca) with a grant on ‘Interpretazione del linguaggio naturale e trattamento efficiente di casi rilevanti di ambiguità semantica’ (EN: *Natural Language Interpretation and Efficient Treatment of relevant cases of Semantic Ambiguity*), Department of Computer Science, University of Turin.
- Nov 2006 - Feb 2008*      **Post-doctoral fellow** (IT: Assegno di Ricerca) with a grant on ‘Interpretazione del linguaggio naturale’ (EN: *Natural Language Interpretation*), Department of Computer Science, University of Turin.
- Feb 2004 - Oct 2006*      **Short Term Researcher** for the European project HOPS (Enabling an Intelligent Natural Language based Hub for the Deployment of Advanced Semantically Enriched Multi-channel Mass-scale Online Public Services).
- Feb 2004 - today*          **Teaching Contracts** for teaching activities as Lecturer, Teaching Assistant, and external Collaborator. These contracts are listed below.

## Nomotika SRL and Technology Transfer

In February 2014, Livio Robaldo became a partner in **Nomotika SRL**, a spin-off of the University of Turin, upon invitation of the founders, due to their interests in his developed tools and resources. The mission of Nomotika SRL is the research and the development of cutting-edge ICT products and services in the legal domain. It combines the experience of Augeos SPA, leader in the Italian ICT market and partner in Nomotika SRL, with the research done by the Department of Computer Science of the University of Turin. The role of Livio Robaldo in Nomotika is contributing to the technology transfer of the research in NLP into the products of the company, first of all **MenslegiS**, an advanced legal document management systems based on legislative XML representation of laws which are retrieved automatically from institutional legislative portals.

The work in Nomotika is not the only technology transfer activity Livio Robaldo carried out. The full list of all Livio Robaldo’s technology transfer activities is reported below:

- September 2014*          **Winner of the project SentiTagger**, sponsored by the Working Capital accelerator (<http://www.workingcapital.telecomitalia.it>), the Telecom Italia program devoted to support new startups and innovative research projects. More details about the SentiTagger project are found below.
- March 2013*              **Private contract** with Iskra SNC for the design and the development of a Java module able to convert a curriculum vitae in pdf or other formats (docx, html, etc.) into an XML where relevant data are tagged.
- June 2012*                **Private contract** between Augeos SRL and the Department of Computer Science, for the design and the development of a Java module able to identify relevant data within financial documents concerning bank credits, by using the TULE parser.
- February 2011*          **Private contract** with Parsig SRL for the design and the development of a Java module able to translate the TULE parser dependency format in a format suitable for the company’s business.

## Projects

Livio Robaldo participated in the financed research projects listed below. He was the **Principal Investigator** of the projects **ProLeMAS** and **SentiTagger** and **WP leader** in the project **DAPRECO**. He coordinated the writing of the project **MIREL**, which involves 16 international partners, at least one for each continent; Livio Robaldo collected the contributions of each partner in **MIREL**, he revised them and added the missing parts, in order to write a coherent project proposal articulated in six WPs. He participated in the writing of the project **LAST-JD RIoE**, of which he is currently the principal responsible for the University of Luxembourg. Finally, Livio Robaldo collaborated in the writing of the projects **BO-ECLI**, **FirstLife**, **EasyTown**, **SEeS@W**, **Librare**, **Giudem**, and **KnowYouAll**, described below.

- **FNR-CORE project “DAPRECO”**. DAPRECO aims at developing a methodology for developing legal ontologies as well as a knowledge base for representing and correlating the norms in the upcoming General Data Protection Regulation (GDPR) and in several ISO standards. The formulae in the knowledge base are asserted in **reified Input/Output logic**, the logic developed in the context of the ProLeMAS project. The aim of this research is providing a measure of the coverage of the GDPR provisions, when certain ISO standards are implemented and certified, which may be used by companies in courts as an argument to avoid liability. The project will be carried out by five researchers: Cesare Bartolini, Andra Giurgiu, Gabriele Lenzini, Livio Robaldo, and Monica Palmirani (external collaborator).
- **Marie Skłodowska-Curie ITN project “LAST-JD RIoE”**. The LAST-JD International Doctorate in “Law, Science, and Technology” is an interdisciplinary integrated doctorate, designed to address new challenges in: (1) Bioethics and Biolaw, (2) ICT Law, and (3) Legal Informatics. The doctorate school was initially retained for funding from EACEA, from 2012 until 2016. Afterwards, LAST-JD students were supported by self-financed fellowships from the Universities in the consortium. In 2018, a new version of LAST-JD, titled LAST-JD RIoE (Rights of the Internet of Everything), has been retained for funding by the Marie Skłodowska-Curie Innovative Training Networks. LAST-JD RIoE involves 24 international partners, including 9 European universities that will host 15 PhD students, two of whom at the University of Luxembourg. Each PhD student will visit some of the other partners in the consortium, thus obtaining the training needed to carry out his PhD activity.
- **Marie Skłodowska-Curie RISE project “MIREL”**. The MIREL (Mining and REasoning with Legal texts) project will create an international and inter-sectorial network to define a formal framework and to develop tools for Mining and REasoning with Legal texts, with the aim of translating these legal texts into formal representations that can be used for querying norms, compliance checking, and decision support. MIREL promotes mobility and staff exchange between SMEs to academics in order to create an inter-continental interdisciplinary consortium in Law and Artificial Intelligence areas including Natural Language Processing, Computational Ontologies, Argumentation, and Logic & Reasoning. MIREL involves 16 partners: *University of Luxembourg, University of Turin, University of Bologna, Stanford University, National ICT Australia, INRIA Sophia Antipolis, University of Huddersfield, Zhejiang University, National Institute of Informatics of Japan, University of Cape Town, Universidad Nacional de La Plata, Universidad Nacional de Córdoba, Universidad Nacional del Sur, APIS Hristovich EOOD, DLVSystem SRL, and Nomotika SRL.*

- **Marie Skłodowska-Curie IF project “ProLeMAS”**. Drawing from Livio Robaldo’s past experience in natural language semantics, parsing, and corpora building, ProLeMAS (Processing Legal language in normative Multi-Agent Systems) aimed at designing a new logic for normative reasoning in multi-agent systems. In particular, ProLeMAS aimed at (1) filling the gap between the current formalizations in deontic logics and the richness of natural language semantics (2) Implementing a pipeline from legal text to ProLeMAS formulae, passing through parsing and reasoning. The supervisor of the project ProLeMAS was prof. Leon van der Torre, University of Luxembourg.
- **e-Justice project (JUST/2014) “BO-ECLI”**. BO-ECLI (Building On the European Case Law Identifier) was an e-Justice project (JUST/2014) aimed at developing a (backwards compatible) 2.0 version of the ECLI-standard, and at implementing an open-source software toolkit for computer-based extraction of legal links, to be connected with ECLI search engine of the European e-Justice portal.
- **Working Capital project “SentiTagger”**. SentiTagger was a project devoted to build a prototype able to automatically tag free text in OpinionMining-ML, the XML format defined in [Robaldo and Di Caro, 2013]. The prototype uses the TULE parser for parsing the input text. Afterwards, a pattern-matching rules system recognizes the linguistic expressions referring to relevant concepts and associate them with individuals of the reference OWL ontology. Finally, linguistic expressions are classified with respect to four classes: positive or negative comment, suggestion, and observation.
- **European FP7 project “EUCases”**. EUCases was a collaborative research project supported by 7th Framework Programme (FP7) funding. The project developed a unique pan-European law and case law Linking Platform transforming multilingual legal open data into linked open data after semantic and structural analysis. The web based EUCases Linking Platform provides services linking EU law and case law with legislative acts and court decisions of six EU member states: Austria, Bulgaria, France, Germany, Italy and United Kingdom. The partners of the project were companies and universities in Bulgaria, Germany, and Italy. Livio Robaldo has been the responsible of the Italian NLP toolkit of EUCases.
- **IoD project “SEeS@W”**. SEeS@W (“Sensing Safety at Work”) was a project financed by the region of Piedmont under the program “Internet of data”. SEeS@W aimed at developing new solutions and novel services for the safety at work, via “Internet of Things (IoT)”, i.e. via sensors connected to Internet, or via “Internet of Persons (IoP)”, i.e. by collecting and analyzing data given by physical persons. The project was implemented in laboratories in the hospital context (Città della Salute e della Scienza of the city of Turin).
- **IoD project “Librare”**. Librare was a project financed by the region of Piedmont under the program “Internet of data”. Librare aimed at creating a new portal to promote social reading and bookcrossing between the citizen of Turin. The portal shows an interactive map where citizen can create initiative related to social reading and bookcrossing or explore and comment on the ones created by others.
- **Smart City Social Innovation project “FirstLife”**. FirstLife is a project financed by the Italian government under the Smart City Social Innovation initiative. FirstLife aims at creating a new social network that allows users to tag events and locations on a local map. Users of FirstLife display a local map geolocating them on which they can tag and enter comments on shops, buildings, events, services, etc. around them. Comments are collected, analyzed, and shown via the social network to the other users. FirstLife aims at encouraging citizens to share information and help each other.

- **Smart City Social Innovation project “EasyTown”**. EasyTown is a project funded by the Italian government in the context of the Smart City Social Innovation initiative. EasyTown aims at developing new technologies for facilitating the access to local normative documents. Administrative procedures are formalized into BPM charts. The citizen could then query the EasyTown system via special interfaces that explain them the administrative procedures step-by-step. Once norms change, the EasyTown system is able to detect, via NLP technologies, which administrative procedures are affected by the changes, i.e. which corresponding BPM charts must be updated.
- **Feasibility study project “Giudem”**. Giudem was a feasibility study project financed by the region of Piedmont under the program of “Innovazione e PMI”. The project aimed at studying the implementation of systems for the dematerialization of documents needed by the administrative procedures within judicial offices. The case study of the project has been the public prosecutor’s office of the city of Asti.
- **Local research project “The role of visual imagery in lexical processing”**. The project involved three departments of the University of Turin: the Department of Philosophy, the Department of Psychology, and the Department of Computer Science. During the project, neuroimaging experiments were carried out to assess hypotheses on how humans understand words (particularly “visually loaded” words). Moreover, a computational model of lexical processing was built in order to study the notion of “visually loaded” lexical item, generate hypotheses about the overall lexical processing, and simulate deficits by selectively “damaging” individual modules.
- **Working Capital project “KnowYouAll”**. KnowYouAll was a project for semantic search in personal textual data that relies on a Named Entity Recognition module and an interactive query system. It was a cloud-based system that synchronizes personal texts, coming from multiple sources like web pages, notes, e-mails, and so forth, and that extracts concepts, entities, and temporal expressions providing a semantic access to the information. The TULE parser was used in order to recognize temporal expressions via pattern-matching rules and to feed support vector machines for recognizing concepts and named entities.
- **Regional research project “LIS4ALL”**. LIS4ALL is the acronym of “Lingua Italiana dei Segni per l’Accesso su Larga scala ad informazioni Localizzate” (EN: *Italian sign language for large-scale access to localised information*). The project aimed at launching the large-scale experimental phase of a new LIS (Italian Sign Language) visualisation service for information and messages geared towards the deaf on mobile terminals. The project considered as its field of application all the notices and announcements that are usually made in a railway station. The project aimed at installing a large number of screens in the station that will display the subtitles of voice announcements as they are made over the loudspeaker and the Italian Sign Language virtual actor view of the same message simultaneously.
- **Regional research project “ATLAS”**. ATLAS is the acronym of “Automatic Translation into Sign Language”. The project was patronized by the region of Piedmont and financed by the program of development of innovative services and it gave the possibility to deaf people to look and understand programs of mass media through automatic translation from the Italian written language into the sign language (LIS) which was visualized by a virtual actor created by computer animation drawing means. The goal of the project, strongly supported by RAI (Radio Televisione Italiana), was the translations of weather forecast into the Italian sign language of the deaf.



- **Regional research project “ICT4LAW”**. ICT4LAW was a 3 years converging technologies project financed by Regione Piemonte. This project aimed at developing beyond state of the art ICT and applying them to the legal field to build the core of a new generation of services. These technologies stemmed from the convergence of ICT methodologies developed in the area of cognitive science, e.g. ontologies, automated analysis of natural language, autonomous agents, neural networks and statistical techniques to analyse quantitative data, and agent-based simulation which adopts the simulative method of cognitive science and apply it to the complexity of social and economic reality. This project applied the newly developed technologies in a synergic way to build a platform of services to support different kinds of users when dealing with legal aspects.
- **FIRB project “TOCAL.IT”**. The project ‘TOCAL.IT: Knowledge-oriented technologies for enterprise aggregation in Internet’ has been funded by Italian Ministry of Education under the FIRB program. The main goal of the project was the application of various ICT techniques, especially the ones devoted to data, knowledge and process modeling, to support the industrial activity. One of the sub-activities of the project concerns the extraction of corporate knowledge via NLP techniques. The NLP group focused its activity on the problem of interpreting NL queries to databases, by exploiting the TULE parser. The activity has been carried out on the radar domain, since one of the industrial partners of the project was a producer of radars.
- **European project “HOPS”**. HOPS is the acronym of “Enabling an Intelligent Natural Language based Hub for the Deployment of Advanced Semantically Enriched Multi-channel Mass-scale Online Public Services)”. The project aimed at addressing the mass-scale deployment of new online public services supported and accessible by voice channels (basically phone, both fixed and mobile), the most accessible and communication means used by European citizens. The project was based on the integration of voice technologies with NLP technologies, complemented by a public administration sector-specific implementation of Semantic Web technologies.

## Developed Corpora

To assess the performance of NLP applications, they need to be evaluated on corpora. For this reason, the development of corpora is of paramount importance in computational linguistics. Nevertheless, unfortunately it is highly time-consuming. The annotation of corpora must be carried out by hand, in order to build reliable annotations. Humans annotators must be hired and provided with semi-automatic instruments that facilitate and control their activity. Livio Robaldo contributed, in different roles, to the development of the following corpora:

### **Turin University Treebank (TUT)**

The Turin University Treebank (TUT) (<http://www.di.unito.it/~tutreeb>), is a collection of morphologically, syntactically and semantically annotated Italian sentences. The native representation format is dependency-oriented and aims at capturing the richness of the predicate-argument structure. The treebank currently contains *3542 Italian sentences*, corresponding to *102150 tokens*. Livio Robaldo developed Java procedures for displaying the annotations in a highly-readable graphical format and for creating new annotations. He supervised the annotation of the TUT section including texts taken from Wikipedia.

### **Penn Discourse Treebank (PDTB)**

The Penn Discourse Treebank (PDTB) (<http://www.seas.upenn.edu/~pdtb/>), is, to date, the largest scale corpus annotated with information related to discourse structure and discourse semantics. There are a total of *40600 tokens* annotated in the latest version of PDTB, i.e. PDTB-2.0. A token could be either an explicit or an implicit connective or a discourse relation for which an implicit connective could not be found, but rather an inferred relation or an entity-based coherence. Livio Robaldo contributed to the definition of the sense annotation schema of the PDTB and he was a validator of many sense annotations stored in the corpus.

### **Phrase Detective corpus**

The Phrase Detective corpus is part of the AnaWiki project, that aims at developing tools to allow and encourage large numbers of volunteers over the Web to collaborate in the creation of semantically annotated corpora. The Phrase Detective corpus (<http://anawiki.essex.ac.uk/phrasedetectors>) is a corpus annotated with information about anaphora including over 162,000 annotations. The annotations are carried out via an online game where annotators compete to each other for winning prizes. Livio Robaldo was an expert annotator of the corpus and contributed to the validation phase. In addition, he developed Java procedures for making the game available for Italian.

### **OpinionMining-ML corpus**

The OpinionMining-ML corpus is a corpus including annotations in OpinionMining-ML, a novel XML-based formalism that Livio Robaldo designed together with Luigi Di Caro. The formalism is described in [Robaldo and Di Caro, 2013]. The corpus includes 1000 comments taken from 2Spaghi (<http://www.2spaghi.it>), one of the biggest Web2.0-based Italian sites that collects and shows comments about restaurants and pizzerias. Livio Robaldo designed the corpus, developed Java tools for facilitating and checking the annotations done, and annotated and validated the 1000 comments. The OpinionMining-ML Corpus has been used to evaluate the performances of the SentiTagger system, in the context of the WCAP project “SentiTagger”.

### **MenslegiS corpus**

The MenslegiS corpus is the corpus of the homonymous system MenslegiS, i.e. the legal document management system distributed by Nomotika SRL. So far, the corpus includes more than 500 documents among compliances, violations, penalties, etc. that have been classified and annotated with respect to the Syllabus ontology, i.e. the ontology of MenslegiS. Livio Robaldo designed Java tools that, by exploiting the TULE parser, identify concepts within free text, in order to help annotators to link textual chunks to the concepts in Syllabus.

## **Networking activities**

Livio Robaldo **attended more than 40 conferences and workshops**, e.g. ECAI, ICAIL, JURIX, IUI, LREC, etc., where a paper he (co-)authored was accepted as either a full presentation or a poster. He also **reviewed more than 20 papers** submitted to conferences and workshops, e.g. IJCAI, ECAI, CogSci, LREC, etc., and to the **Journal of Logic, Language and Information** and the **Journal of Semantics**.

Further details of Livio Robaldo’s networking activities may be found below in the respective sections.

## **Special Issues, Technical Committees, Invited speaker, Seminars**

- **Membership of the Technical Committee** “OASIS LegalRuleML”, a standardization initiative under OASIS, aiming at creating an XML standard for representing semantic/logical content of legal documents, for use by both humans and machines.
- **Principal guest editor of the Special Issue** “Reasoning on Legal Texts”, the IfCoLog Journal of Logics and their Applications.
- **Principal guest editor of the Special Issue** “Natural Language Processing for Legal Texts”, the Journal of Artificial Intelligence and Law.
- **Promoter of a Framework Agreement** between the University of Luxembourg and the University of Turin, centered on research in legal informatics.
- **Invited speaker at USC/ISI**, Marina del Rei (Los Angeles), Nov 2017. Livio Robaldo was invited to present reified Input/Output logic [Robaldo and Sun, 2017], the main scientific achievement of the ProLeMAS project, to prof. J.R. Hobbs’s research group. Reified Input/Output logic combines Input/Output logic, a deontic logic (co-)authored by prof. van der Torre, with the reification-based approach to Natural Language Semantics authored by prof. J.R. Hobbs.
- **Seminar(s) at Stanford University**, Oct-Dec 2017. Livio Robaldo was visiting Stanford University from October to December 2017 in the context of MIREL, where he presented the project MIREL and his ongoing research in several seminars.
- **Invited speaker at IUI 2013 conference**, Santa Monica (Los Angeles), Mar 2013. Livio Robaldo was an invited speaker of the conference. He presented the Phrase Detective corpus, introduced in [Poesio et al, 2013].
- **Seminar at University of Luxembourg**, University of Luxembourg, Dec 2013. Livio Robaldo was visiting the University of Luxembourg in December 2013, where he was invited to present in a seminar his logical framework for dealing with Independent Set readings [Robaldo 2011].
- **Seminari di Filosofia del Linguaggio**, seminar series organized by the Department of Philosophy of the University of Milan, Feb 2013. Livio Robaldo was one of the invited speakers for the seminar series. He presented his logical framework for dealing with Independent Set readings [Robaldo 2011].
- **Seminar at Brandeis University**, Brandeis University, Waltham (Boston), Jul 2010. Livio Robaldo was visiting the university of Brandeis in July 2010, where he was invited to present in a seminar his logical framework for dealing with Independent Set readings [Robaldo 2011].
- **Seminar at Trento University**, Trento University, Trento, Feb 2010. Livio Robaldo was invited by the University of Trento to present in a seminar his logical framework for dealing with Independent Set readings [Robaldo 2011].
- **Seminar at Trento University**, Trento University, Trento, May 2008. Livio Robaldo was invited by the University of Trento to present in a seminar the TULE Parser and the Turin University Treebank (TUT).

## Organization of conferences, workshops, and scientific events

Livio Robaldo organized the following scientific initiatives:

- **Member of the local organization committee of JURIX 2017**, the 30th international conference on Legal Knowledge and Information Systems.

- **Chair of the Workshop “Mining and Reasoning with Legal Texts”**, collocated with the “The 16th International Conference on Artificial Intelligence and Law (ICAAIL 2017)” conference.
- **Chair of the Workshop “Mining and Reasoning with Legal Texts”**, collocated with the “The 29th international conference on Legal Knowledge and Information Systems (JURIX 2016)” conference.
- **Chair of the Tutorial “Mining and Reasoning with Legal Documents”**, collocated with the “The biennial European Conference on Artificial Intelligence (ECAI 2016)” conference.
- **Chair of the Tutorial “Normative MAS and the Law”**, collocated with the “Principles and Practice of Multi-Agent Systems (PRIMA 2015)” conference.
- **Chair of the Workshop on Language and Semantic Technology for Legal Domain (LST4LD)**, collocated with RANLP 2015, in Hissar (Bulgaria).

Moreover, he was member of the Program Committee of the following conferences/workshops:

- **JURIX 2018**, i.e. the 31th International Conference on Legal Knowledge and Information Systems, Groningen, The Netherlands, 2018.
- **IJCAI-ECAI 2018**, i.e. the 27th International Joint Conference on Artificial Intelligence and the 23rd European Conference on Artificial Intelligence conference, 2018.
- **RuleML+RR 2018**, i.e. RuleML+RR 2018, the 2nd International Joint Conference on Rules and Reasoning.
- **MIREL2018 workshop**, i.e. the Workshop on Mining and Reasoning on Legal texts, Luxembourg, 2018.
- **JURIX2017 conference**, i.e. the 30th International Conference on Legal Knowledge and Information Systems, Luxembourg, 2017.
- **AICOL2017 workshop**, i.e. The 9th Workshop on Artificial Intelligence Approaches to the Complexity of Legal Systems (AICOL), collocated at the 30th International Conference on Legal Knowledge and Information Systems (JURIX2017)
- **ICAAIL conference**, i.e. The 16th International Conference on Artificial Intelligence and Law, London, UK, 2017.
- **COLIEE2017 workshop**, i.e. The Competition on Legal Information Extraction and Entailment, collocated at the 11th International Workshop on Juris-informatics (JURISIN 2016).
- **AICOL2016 workshop**, i.e. The 7th Workshop on Artificial Intelligence Approaches to the Complexity of Legal Systems (AICOL), collocated at the 29th International Conference on Legal Knowledge and Information Systems (JURIX2016)
- **LK&SW-2016 workshop**, i.e. The third Workshop on Legal Knowledge and the Semantic Web (LK&SW-2016) collocated at the 20th International Conference on Knowledge Engineering and Knowledge Management.
- **JURIX2016 conference**, i.e. the 29th International Conference on Legal Knowledge and Information Systems, Nice, France, 2016.
- **NorMas2016 conference**, i.e. the 2016 Normative Multiagent Systems Workshop, The Hague, The Netherlands, 2016.
- **ECAI2016 conference**, i.e. The biennial European Conference on Artificial Intelligence, The Hague, The Netherlands, 2016.
- **AICOL2015 conference**, i.e. the European Conference on Artificial Intelligence, The Hague, The Netherlands, 2016.

- **NorMas2015 conference**, i.e. the 2015 Normative Multiagent Systems Workshop, The Hague, The Netherlands, 2015.
- **JURIX2015 conference**, i.e. the 28th International Conference on Legal Knowledge and Information Systems, Braga, Portugal, 2015.
- **IANC2015 conference**, i.e. the First International Akoma Ntoso Conference, Washington-DC, USA, 2015.
- **AIoT14 workshop**, i.e. the International Workshop on Affordances in the Internet of Things, Rome, Italy, 2014.

## Teaching activity

Livio Robaldo started his teaching activity in 2007, after he earned his Ph.D. His teaching activity includes **923 hours of teaching** and he has been **Lecturer of twelve MSc courses** at the University of Turin. Also, he provided administrative and organizational support for several courses, as well as for the **LAST-JD International Doctorate in Law Science and Technology** (<http://www.last-jd.eu>). He **co-supervised one bachelor student** (Frederick Tang), **two master students** (Serena Villata and Jurij Di Carlo) and **five Ph.D. students** (Llio Humphreys, Kolawole Adebayo, Xin Sun, Rohan Nanda, Giovanni Siragusa).

The list of Livio Robaldo's teaching activities is reported below:

<i>May 2017</i>	<b>Seminar Lecturer</b> of the seminar "Introduction to Computational Linguistics", for the Joint International Doctoral (Ph.D.) Degree in Law, Science and Technology (LAST-JD), University of Turin, 6 hours of teaching.
<i>May 2016</i>	<b>Seminar Lecturer</b> of the seminar "Introduction to Computational Linguistics", for the Joint International Doctoral (Ph.D.) Degree in Law, Science and Technology (LAST-JD), University of Turin, 6 hours of teaching.
<i>February 2015</i>	<b>Lecturer</b> of the undergraduate course of "Sistemi Informativi", SAA Administration business school, University of Turin, 84 hours of teaching.
<i>October 2014</i>	<b>Lecturer</b> of the undergraduate course of "Tecnologie di Servizi Web", SAA Administration business school, University of Turin, 57 hours of teaching.
<i>February 2014</i>	<b>Lecturer</b> of the undergraduate course of "Sistemi Informativi", SAA Administration business school, University of Turin, 78 hours of teaching.
<i>October 2013</i>	<b>Lecturer</b> of the undergraduate course of "Tecnologie di Servizi Web", SAA Administration business school, University of Turin, 53 hours of teaching.
<i>February 2012</i>	<b>Lecturer</b> of the undergraduate course of "Sistemi Informativi", SAA Administration business school, University of Turin, 60 hours of teaching.
<i>February 2012</i>	<b>Lecturer</b> of the undergraduate course of "Tecnologie di Servizi Web", SAA Administration business school, University of Turin, 53 hours of teaching.
<i>February 2011</i>	<b>Lecturer</b> of the undergraduate course of "Informatica", Department of Psychology, course in "Psicologia clinica e di comunità", University of Turin, 30 hours of teaching.
<i>February 2011</i>	<b>Lecturer</b> of the undergraduate course of "Informatica", Department of Psychology, course in "Scienze e Tecniche Psicologiche", University of Turin, 30 hours of teaching.

<i>February 2011</i>	<b>Lecturer</b> of the undergraduate course of “Tecnologie di Servizi Web”, SAA Administration business school, University of Turin, 53 hours of teaching.
<i>February 2010</i>	<b>Lecturer</b> of the undergraduate course of “Tecnologie di Servizi Web”, SAA Administration business school, University of Turin, 53 hours of teaching.
<i>February 2009</i>	<b>Teaching Assistant</b> of the undergraduate course of “Laboratorio di Servizi Web”, Faculty of Mathematical, Physical, and Natural Sciences, University of Turin, 25 hours of teaching.
<i>October 2008</i>	<b>Lecturer</b> of the undergraduate course “Informatica applicata alla Comunicazione Multimediale”, Master Degree in “Traduzione”, Faculty of Languages and Foreign literature, University of Turin, Academic year 2008/2009, 60 hours of teaching.
<i>October 2007</i>	<b>Teaching Assistant</b> of the undergraduate course of “Programmazione I-II e Laboratorio”, Faculty of Mathematical, Physical, and Natural Sciences, University of Turin, 50 hours of teaching.
<i>October 2007</i>	<b>Teaching Assistant</b> of the undergraduate course of “Informatica I and II”, Faculty of Mathematical, Physical, and Natural Sciences, University of Turin, 50 hours of teaching.
<i>October 2007</i>	<b>Lecturer</b> of the undergraduate course “Laboratori di Informatica”, Faculty of Philosophy, University of Turin, 60 hours of teaching.
<i>October 2007</i>	<b>Teaching Assistant</b> of the undergraduate course of “Informatica I and II”, Faculty of Mathematical, Physical, and Natural Sciences, University of Turin, 50 hours of teaching.
<i>2007-2009</i>	Several <b>private contracts</b> for the teaching basic concepts of NLP, Predicate Logic, XML, and SQL at the high school Liceo V. Alfieri, Turin, and private companies. 118 hours of teaching.

## Research Interests and Scientific Activity

Livio Robaldo’s research activity spans over several research topics:

- (a) **Legal Informatics.**
- (b) **Dependency parsing.**
- (c) **NL quantification and Semantic underspecification.**
- (d) **Sentiment analysis.**
- (e) **Discourse semantics.**
- (f) **Anaphora resolution.**
- (g) **Computational ontologies.**
- (h) **Temporal and event expressions.**
- (i) **Automatic processing of sign language.**

The next subsections briefly describe the results and the ongoing work in each research activity listed in (a)-(i). The list of publications concludes the section and the CV.

## (a) Legal Informatics

Livio Robaldo is currently working on the project **DAPRECO**. On parallel, he follows the activities of the **MIREL** project, by promoting the research among the partners and by following the implementation of the secondments.

Livio Robaldo started working in legal informatics in the context of the **ICT4LAW project**, funded by Regione Piemonte. The ICT4LAW project led to the design and the implementation of **Eunomos**, an advanced legal document management system based on legislative XML representation of laws which are retrieved automatically from institutional legislative portals. A commercial version of Eunomos, called **MenslegiS**, is distributed by Nomotika SRL. [Boella et al, 2016] illustrate Eunomos’s main functionalities.

Livio Robaldo worked on MenslegiS by trying to use the TULE parser for extending its capabilities. In particular, TULE was used for automatically identifying in free text the concepts of the Legal Taxonomy Syllabus, i.e. the ontology of Eunomos, for ontology learning in the legal domain [Boella et al., 2014], for classifying norms [Robaldo et al, 2012], for classifying legislation into the EuroVoc corpus [Boella et al, 2013a], and for identifying roles in prescriptions, which are individual legal obligations derived from legislation [Boella et al, 2013b]. All prototypes and techniques developed in these activities have been used in the **EUCases project**. For this reason, Livio Robaldo has been invited to become a partner of **Nomotika SRL**, a spin-off of the University of Turin.

Drawing from his gained expertise on the aforementioned projects, as well as from his past experience in natural language semantics, parsing, and corpora building, in 2015 Livio Robaldo proposed and won the Marie Skłodowska-Curie IF project “ProLeMAS”. The project ProLeMAS has been proposed for (1) filling the gap between the current formalizations in deontic logics and the richness of natural language semantics (2) Implementing a pipeline from legal text to ProLeMAS formulae, passing through parsing and reasoning.

Concerning the objective (1), ProLeMAS designed a logic, called **reified Input/Output logic**, that incorporates prof. Hobbs’ logic, which has been used by Livio Robaldo in his past research works on natural language semantics, e.g., [Robaldo and Miltsakaki, 2014], into Input/Output logic, proposed and extensively studied by prof. van der Torre - the supervisor of ProLeMAS - and that appears as one of the new achievements in deontic logic in recent years.

Concerning the objective (2), drawing from the prototypes implemented in the project EUCases, ProLeMAS extended the granularity of the annotations in EUCases fit to tag named entities occurring in laws and case law, such as lawyers, judges, roles, companies, institutions, dates, etc. as well as norms occurring in laws such as obligations, permissions, powers, etc. The latter are associated with reified Input/Output logic formulae in a semi-automatic way by using the TULE parser.

Reified Input/Output logic is currently used in DAPRECO in order to model the provisions in the GDPR and those in some security ISO standards, and correlate the former with the latter. The aim is to provide a measure of the coverage of the GDPR provisions, when certain ISO standards are implemented and certified, which may be used by companies in courts as an argument to avoid liability. The reified Input/Output formulae are codified in LegalRuleML, a recent XML standard for the legal domain able to connect logical formalizations with concepts in legal ontologies and legal documents structured in the Akoma Ntoso XML legal standard.

## (b) Dependency parsing

Livio Robaldo collaborates in the development of the **Turin University Linguistic Environment (TULE)** and the **Turin University Treebank (TUT)**. The former is a morpho-syntactic analyzer, while the latter is a corpus including more than 3500 Italian sentences. TULE and TUT share the same Dependency format<sup>1</sup>. TULE has been developed by prof. Leonardo Lesmo during the past decades. It is written in Lisp, and currently supports four languages (Italian, English,

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<sup>1</sup><http://www.di.unito.it/~tutreeb>

Spanish, Catalan). Nevertheless, it has good performances for Italian only, while the improvement of its performance in the other supported languages is seen as the object of future research. TULE was used for the semi-automatic annotation of the sentences in TUT.

Livio Robaldo made TULE available to the scientific community by adding instructions that converted it as a server. Then he developed a user-friendly **Java GUI Client** to TULE<sup>2</sup>. The Client allows to contact the TULE Server via Internet, send it NL sentences, retrieve the corresponding syntactic analyses, and display them in a graphical format.

Livio Robaldo used the Java interface to TULE in several research and technology transfer activities, among which **Legal Informatics**, **Sentiment Analysis**, **Anaphora resolution**, and **Temporal and event expressions**.

### (c) NL Quantification and Semantic Underspecification

In his Ph.D. thesis, Livio Robaldo proposed a new semantic underspecified formalism, termed ‘Dependency Tree Semantics’ (DTS). DTS is able to underspecify quantifier scope via Skolem-like constructs. In DTS, ambiguities on the sets of entities involved are represented via functional dependencies, i.e. Skolem-like functions, that may be underspecified. Well-formed structures in DTS are graphs between predicates and discourse referents, denoted by quantifiers, determiners, proper names, etc. Those graphs constitute a semantic underspecified representation of the sentence. In order to disambiguate quantifier scope ambiguities, further functional dependencies between discourse referents are inserted. They resemble Skolem functions.

By allowing disambiguation in terms of functional dependencies rather than in terms of quantifier scope embeddings, we achieve the expressivity needed to represent readings where two or more sets of entities are independent of one another. Those reading have been termed in [Robaldo, 10a] as ‘Independent Set (IS) readings’.

Defining a model theory for IS readings is rather complex, in that the incorporation of independent sets in the standard Generalized Quantifier approach requires the introduction of particular clauses termed Maximality Conditions. Those require the involved sets of entities to be the maximal sets that satisfy the predications. [Robaldo, 10a] defines a logical framework that generates Second Order Logic formulae able to represent the truth conditions of Branching Quantifier readings and non-IS (linear) reading. Livio Robaldo’s Ph.D. thesis defines an algorithm to translate DTS fully disambiguated structures into those formulae. On the other hand, [Robaldo, 10b] studies how interpretation and inference are carried out on the maximal terms occurring in [Robaldo, 10a]’s formulae and [Robaldo, 11] generalizes the logical framework in [Robaldo, 10a] in order to represent any IS reading, including Collective, Cumulative and Cover readings.

Finally, [Robaldo, 13] investigates the well-known property of Conservativity in [Robaldo, 11]’s framework and [Robaldo and Di Carlo, 2013] defines a new version DTS that achieves expressive completeness with respect to these readings.

### (d) Sentiment Analysis

Livio Robaldo started working on Sentiment Analysis together with Luigi Di Caro by defining a new XML formalism, called OpinionMining-ML, for tagging users’ opinions on products and services. The key idea of OpinionMining-ML’s design is to associate users’ attitude and sentiment with the objects they are about (called facets). In other words, the XML formalism provides tags for (1) Annotating facets, i.e. the objects or the features referred to by the comments, and organize them into an ontology, (2) Annotating the kind of expressive statement, i.e. if it is either an appraisal, or a suggestion, or a comparison, or a simple observation, etc. (3) Associating expressive statements with facets, i.e. indicating the object referred to by an expressive statement.

The design of the XML formalism has been guided by the analysis of 3000 comments about restau-

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<sup>2</sup><http://www.tule.di.unito.it>



rants taken from 2spaghi (<http://www.2spaghi.it>), one of the biggest web2.0 sites about Italian restaurants and pizzerias. 1000 comments out of the mentioned 3000 ones has been manually annotated in OpinionMining-ML. OpinionMining-ML and the annotated corpus is illustrated in [Robaldo and Di Caro, 2013]. The work in [Robaldo and Di Caro, 2013] allowed Livio Robaldo to win the WCAP 2014 competition, with the **SentiTagger project**. SentiTagger is the name of a rule-based system for sentiment analysis that analyzes the text via the TULE parser and tags comments according to the OpinionMining-ML format.

### (e) Discourse Semantics

During his first visiting period at the University of Pennsylvania, Livio Robaldo started collaborating with the Penn Discourse Treebank (PDTB) research group. The Penn Discourse Treebank is a corpus developed at the Institute for Research in Cognitive Science of the University of Pennsylvania (UPenn). The PDTB is, to date, the largest annotation effort at the discourse level, providing annotations of explicit and implicit discourse connectives. It provides annotations of the argument structure, attribution and semantics of discourse connectives.

Livio Robaldo helped the writing of the PDTB 2.0 annotation manual [Prasad et al. 08a], and the sense annotation in the release 2.0 of the corpus [Miltsakaki et al., 2008]. Later, he focuses on Concession, which appears to be one of the trickiest semantic discourse relations. Concession is a semantic relation between two sentence-arguments where one of them creates an expectation and the other one denies it. Typical discourse connectives that convey Concession are “although”, “but”, “however”, “nevertheless”, etc.

Livio Robaldo, together with Eleni Miltsakaki, defined in [Robaldo and Miltsakaki, 2014] a semantics of Concession based on the data included in the PDTB. The research work is based on an empirical study conducted on 1000 occurrences of concessive relations taken from the PDTB. The analysis led to the identification of four possible sources of Expectation. Then, a uniform formalization of three of those sources in the event-based logic defined by prof. Jerry R. Hobbs is proposed.

### (f) Anaphora Resolution

Livio Robaldo worked on Anaphora Resolution by collaborating with the University of Trento and the University of Essex in the **AnaWiki Project**<sup>3</sup>. The aim of AnaWiki is the development of tools to allow and encourage large numbers of volunteers over the Web to collaborate in the creation of semantically annotated corpora.

Livio Robaldo was an expert player and a validator of the **Phrase Detective** game<sup>4</sup>. Phrase Detective aims at building a large corpus of anaphoric expressions. Players are requested to associate anaphoric expressions with their referents. The Phrase Detective system and the data collected are extensively described in [Poesio et al, 2013].

Besides helping the annotation of the data through the system, Livio Robaldo made the game available in Italian by exploiting the TULE parser. In particular, he developed a Java converter from TULE to the XML format used in the Phrase Detective framework.

### (g) Computational ontologies

Livio Robaldo carried out research on computational ontologies during the European **project HOPS**. He contributed both in the design of the OWL ontologies needed in the project and in the design of the software using the TULE parser and the ontologies for interpreting NL queries to databases. In particular, he worked at the integration of OWL ontologies in the TULE parser by implementing a Java converter from OWL to a lisp-readable format. The research activity done by Livio Robaldo in the project HOPS has been documented in [Lesmo and Robaldo 07c], [Lesmo and

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<sup>3</sup><http://anawiki.essex.ac.uk>

<sup>4</sup><http://anawiki.essex.ac.uk/phrasedetectives>.

Robaldo 07a], and [Lesmo and Robaldo 06a]. Later, the results and the software obtained in the project HOPS have been exploited and extended in the Firb project **TOCAL.IT**.

Afterwards, Livio Robaldo started working on computational ontologies again with respect to the **project “The role of visual imagery in lexical processing”**. One of the goals of the project was to develop a computational ontology, and procedures using it, that adheres to the notion of “visually loaded” lexical item.

#### (h) Temporal and event expressions

Livio Robaldo carried out research on temporal and event expressions by working on **It-TIME-ML**, the Italian version of TIME-ML (<http://timeml.org/site/index.html>). TIME-ML allows to annotate events and temporal expressions within textual documents, and to associate the latter with the former. Thus, it is possible to order the events in chronological order, in order to enhance the performances of Information Retrieval systems.

The work on the topic was mainly focused toward the static annotation of textual documents. Livio Robaldo started working on the computational aspects by developing Java modules that builds It-TIME-ML documents starting from Italian text, by exploiting the TULE parser. The results of the prototype are published in [Robaldo et al., 2011b].

Afterwards, Livio Robaldo used and extended the software presented in [Robaldo et al., 2011b] in the **KnowYouAll project**, devoted to the development of a cloud-based system that extracts concepts, entities, and temporal expressions providing a semantic access to the information.

#### (i) Automatic processing of sign language

Livio Robaldo participated in the **project ATLAS** and the **project LIS4ALL**, both devoted to translate Italian texts into LIS (Italian Sign Language) representations. The two projects aimed at translating Italian sentences on different domains (weather forecast for ATLAS and train announcements for LIS4ALL) into written representations of LIS. The latter are then given in input to a planner that controls a virtual moving character that displays the corresponding gestures.

The translation from Italian into LIS is done by firstly translating Italian sentences into semantic intermediate logical forms which are in turn translated into LIS representations. Livio Robaldo contributed to the design and the implementation of the intermediate logical format, and the ontology to which the concepts identified in the sentences are mapped.

## Publications

### *International Journals*

- [Robaldo and Sun, 2017] Robaldo, L. and Sun, X.: *Reified Input/Output logic: Combining Input/Output logic and Reification to represent norms coming from existing legislation*. The Journal of Logic and Computation, to appear.
- [Sun and Robaldo, 2017] Sun, X. and Robaldo, L.: *On the Complexity of Input/Output Logic*. The Journal of Applied Logic, to appear.
- [Sun et al., 2017b] Sun, X., Zhao, X., and Robaldo, L.: *Ali Baba and the Thief, Convention Emergence in Games*. The Journal of Artificial Societies and Social Simulation, to appear.
- [Sun et al., 2017a] Sun, X. and Zhao, X. and Robaldo, L.: *Norm-based deontic logic for access control, some computational results*. Future Generation Computer Systems, to appear.

- [Ajani et al., 2017] Ajani, G. and Boella, G. and Di Caro, L. and Robaldo, L. and Humphreys, L. and Praduroux, S. and Rossi, P. and Violato, A.: *The European legal taxonomy syllabus: A multi-lingual, multi-level ontology framework to untangle the web of European legal terminology*. Applied Ontology, Vol. 11 (4), pp. 325-375, 2016
- [Boella et al., 2016] Boella, G. and Di Caro, L. and Humphreys, L. and Robaldo, L. and Rossi, P. and van der Torre, L.: *Eunomos, a legal document and knowledge management system for the Web to provide relevant, reliable and up-to-date information on the law*. Artificial Intelligence and Law, Vol. 24 (245).
- [Robaldo and Miltsakaki, 2014] L. Robaldo and E. Miltsakaki: *Corpus-driven Semantics of Concession: Where do Expectations Come from?*. Discourse & Dialogue, Vol 5, No 1.
- [Robaldo et al, 2014] L. Robaldo, J. Szymanik, B. Meijering: *On the identification of quantifiers' witness sets: a study of multi-quantifier sentences*. The Journal of Logic, Language, and Information. Vol. 23, No 1, pp 53-81.
- [Boella et al, 2014] G. Boella, L. Di Caro, A. Ruggeri, L. Robaldo: *Learning from Syntax Generalizations for Automatic Semantic Annotation*. The Journal of Intelligent Information Systems. Vol. 43(2), pp. 231-246.
- [Robaldo, 2013] L. Robaldo: *Conservativity: a necessary property for the Maximization of witness sets*. The Logic Journal of the IGPL, 21 (5), pp. 853-878.
- [Robaldo and Di Carlo, 2013] L. Robaldo and J. Di Carlo: *Flexible disambiguation and Expressive completeness in Dependency Tree Semantics*. The Journal of Semantics, 30 (2).
- [Robaldo and Di Caro, 2013] L. Robaldo and L. Di Caro: *OpinionMining-ML*. Computer Standards & Interfaces, 35 (5).
- [Poesio et al, 2013] M. Poesio, J. Chamberlain, U. Kruschwitz, L. Robaldo, L. Ducceschi: *Phrase Detectives: Utilizing Collective Intelligence for Internet-Scale Language Resource Creation*. ACM Transactions on Interactive Intelligent Systems. 3 (1).
- [Robaldo 2011] L. Robaldo: *Distributivity, Collectivity, and Cumulativity in terms of (In)dependence and Maximality*. The Journal of Logic, Language, and Information, 20(2), pp. 233-271. 2011.
- [Robaldo 2010b] L. Robaldo: *Interpretation and Inference with Maximal referential terms*, The Journal of Computer and System Sciences, 76 (5), pp. 373-388. 2010.
- [Robaldo 2010a] L. Robaldo: *Independent Set readings and Generalized Quantifiers*, The Journal of Philosophical Logic, 39 (1), pp. 23-58, 2010.

### ***Conferences, workshops, technical reports***

- [Palmirani et al, 2018b] M. Palmirani, C. Bartolini, M. Martoni, L. Robaldo, A. Rossi: *Legal Ontology for modelling GDPR concepts and norms*, in proc. of the 31th international conference on Legal Knowledge and Information Systems (JURIX 2018), Groningen, 2018.
- [Antoniou et al, 2018] Antoniou, G., Baryannis, G., Batsakis, S., Governatori, G., Robaldo, L., Siragusa, G. and Tachmazidis, I.: *Legal Reasoning and Big Data: Opportunities and Challenges*, in proc. of the 3rd Mining and Reasoning on Legal text (MIREL2018) workshop.
- [Palmirani et al, 2018b] M. Palmirani, M. Martoni, A. Rossi, C. Bartolini, L. Robaldo: *PrOnto: Privacy Ontology for Legal Compliance*, in proc. of the the 18th European Conference on Digital Government (EDGE2018).

- [Palmirani et al, 2018a] M. Palmirani, M. Martoni, A. Rossi, C. Bartolini, L. Robaldo: *PrOnto: Privacy Ontology for Legal Reasoning*, in proc. of the 7th International Conference on Electronic Government and the Information Systems Perspective (EGOVIS 2018).
- [Nanda et al, 2017c] R. Nanda, K.J. Adebayo, L. Di Caro, G. Boella, L. Robaldo: *Legal Information Retrieval Using Topic Clustering and Neural Networks*, in proc. of COLIEE 2017, 4th Competition on Legal Information Extraction and Entailment, Tokyo, Japan, 2017.
- [Nanda et al, 2017b] R. Nanda, G. Siragusa, L. Di Caro, M. Theobald, G. Boella, L. Robaldo, F. Costamagna: *Concept Recognition in European and National Law*, in proc. of The 30th international conference on Legal Knowledge and Information Systems (JURIX 2017), Luxembourg, 2017.
- [Nanda et al, 2017a] R. Nanda, L. Di Caro, G. Boella, H. Konstantinov, T. Tyankov, D. Traykov, H. Hristo, F. Costamagna, L. Humphreys, L. Robaldo, M. Romano: *A Unifying Similarity Measure for Automated Identification of National Implementations of European Union Directives*, in proc. of the 16th International Conference on Artificial Intelligence and Law (ICAIL), London, 2017.
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