IN PARTNERSHIP WITH:
Université de Grenoble Alpes

Activity Report 2019

Project-Team MOEX

Evolving Knowledge

IN COLLABORATION WITH: Laboratoire d'Informatique de Grenoble (LIG)

RESEARCH CENTER
Grenoble - Rhône-Alpes

THEME
Data and Knowledge Representation and Processing

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Project-Team MOEX

Creation of the Team: 2017 January 01, updated into Project-Team: 2017 November 01

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Other Research Topics and Application Domains:

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1. Team, Visitors, External Collaborators

Research Scientist

Jérôme Euzenat [Team leader, Inria, Senior Researcher, HDR]

Faculty Members

Manuel Atencia [Univ Grenoble Alpes, Associate Professor]
Jérôme David [Univ Grenoble Alpes, Associate Professor]

PhD Students

Yasser Bourahla [Inria, PhD Student, from Oct 2019]
Khadija Jradeh [Univ Grenoble Alpes, PhD Student]
Line Van Den Berg [Univ Grenoble Alpes, PhD Student]

Interns and Apprentices

Jimmy Avae [Inria, from May 2019 until Jun 2019]
Alice Caporali [Univ Grenoble Alpes, from Apr 2019 until Jun 2019]
Robin Couret [Inria, from May 2019 until Jun 2019]
Fatima Danash [Inria, from Feb 2019 until Jun 2019]
Basile Legal [Univ Grenoble Alpes, from Apr 2019 until May 2019]
Michael Toth [Inria, from Jun 2019 until Sep 2019]

Administrative Assistants

Alexandra Fitzgerald [Inria, Administrative Assistant, until Sep 2019]
Julia Di Toro [Inria, Administrative Assistant, from Oct 2019]

2. Overall Objectives

2.1. Overall Objectives

Human beings are apparently able to communicate knowledge. However, it is impossible for us to know if we share the same representation of knowledge.

mOeX addresses the evolution of knowledge representations in individuals and populations. We deal with software agents and formal knowledge representation. The ambition of the mOeX project is to answer, in particular, the following questions:

- How do agent populations *adapt* their knowledge representation to their environment and to other populations?
- How must this knowledge *evolve* when the environment changes and new populations are encountered?
- How can agents preserve knowledge *diversity* and is this diversity beneficial?

We study them chiefly in a well-controlled computer science context.

For that purpose, we combine knowledge representation and cultural evolution methods. The former provides formal models of knowledge; the latter provides a well-defined framework for studying situated evolution.

We consider knowledge as a culture and study the global properties of local adaptation operators applied by populations of agents by jointly:

- *experimentally* testing the properties of adaptation operators in various situations using experimental cultural evolution, and
- *theoretically* determining such properties by modelling how operators shape knowledge representation.

We aim at acquiring a precise understanding of knowledge evolution through the consideration of a wide range of situations, representations and adaptation operators.

In addition, we still investigate RDF data interlinking with link keys, a way to link entities from different data sets.

3. Research Program

3.1. Knowledge representation semantics

We work with semantically defined knowledge representation languages (like description logics, conceptual graphs and object-based languages). Their semantics is usually defined within model theory initially developed for logics.

We consider a language L as a set of syntactically defined expressions (often inductively defined by applying constructors over other expressions). A representation ($o \subseteq L$) is a set of such expressions. It may also be called an ontology. An interpretation function (I) is inductively defined over the structure of the language to a structure called the domain of interpretation (D). This expresses the construction of the “meaning” of an expression in function of its components. A formula is satisfied by an interpretation if it fulfills a condition (in general being interpreted over a particular subset of the domain). A model of a set of expressions is an interpretation satisfying all the expressions. A set of expressions is said consistent if it has at least one model, inconsistent otherwise. An expression (δ) is then a consequence of a set of expressions (o) if it is satisfied by all of their models (noted $o \models \delta$).

The languages dedicated to the semantic web (RDF and OWL) follow that approach. RDF is a knowledge representation language dedicated to the description of resources; OWL is designed for expressing ontologies: it describes concepts and relations that can be used within RDF.

A computer must determine if a particular expression (taken as a query, for instance) is the consequence of a set of axioms (a knowledge base). For that purpose, it uses programs, called provers, that can be based on the processing of a set of inference rules, on the construction of models or on procedural programming. These programs are able to deduce theorems (noted $o \vdash \delta$). They are said to be sound if they only find theorems which are indeed consequences and to be complete if they find all the consequences as theorems.

3.2. Data interlinking with link keys

Vast amounts of RDF data are made available on the web by various institutions providing overlapping information. To be fully exploited, different representations of the same object across various data sets, often using different ontologies, have to be identified. When different vocabularies are used for describing data, it is necessary to identify the concepts they define. This task is called ontology matching and its result is an alignment A, i.e. a set of correspondences $\langle e, r, e' \rangle$ relating entities e and e' of two different ontologies by a particular relation r (which may be equivalence, subsumption, disjointness, etc.) [4].

At the data level, data interlinking is the process of generating links identifying the same resource described in two data sets. Parallel to ontology matching, from two datasets (d and d') it generates a link set, L made of pairs of resource identifier.

We have introduced link keys [4], [1] which extend database keys in a way which is more adapted to RDF and deals with two data sets instead of a single relation. An example of a link key expression is:

$$\{\langle \mathsf{auteur}, \mathsf{creator} \rangle\}\{\langle \mathsf{titre}, \mathsf{title} \rangle\}\ linkkey\ \langle \mathsf{Livre}, \mathsf{Book} \rangle$$

stating that whenever an instance of the class Livre has the same values for the property auteur as an instance of class Book has for the property creator and they share at least one value for their property titre and title, then they denote the same entity. More precisely, a link key is a structure $\langle K^{eq}, K^{in}, C \rangle$ such that:

- K^{eq} and K^{in} are sets of pairs of property expressions;
- C is a pair of class expressions (or a correspondence).

Such a link key holds if and only if for any pair of resources belonging to the classes in correspondence such that the values of their property in K^{eq} are pairwise equal and the values of those in K^{in} pairwise intersect, the resources are the same. Link keys can then be used for finding equal individuals across two data sets and generating the corresponding owl:sameAs links. Link keys take into account the non functionality of RDF data and have to deal with non literal values. In particular, they may use arbitrary properties and class expressions. This renders their discovery and use difficult.

3.3. Experimental cultural knowledge evolution

Cultural evolution considers how culture spreads and evolves with human societies [21]. It applies an an idealised version of the theory of evolution to culture. In computer science, cultural evolution experiments are performed through multi-agent simulation: a society of agents adapts its culture through a precisely defined protocol [16]: agents perform repeatedly and randomly a specific task, called game, and their evolution is monitored. This aims at discovering experimentally the states that agents reach and the properties of these states.

Experimental cultural evolution has been successfully and convincingly applied to the evolution of natural languages [12], [23]. Agents play *language games* and adjust their vocabulary and grammar as soon as they are not able to communicate properly, i.e. they misuse a term or they do not behave in the expected way. It showed its capacity to model various such games in a systematic framework and to provide convincing explanations of linguistic phenomena. Such experiments have shown how agents can agree on a colour coding system or a grammatical case system.

Work has recently been developed for evolving alignments between ontologies. It can be used to repair alignments better than blind logical repair [19], to create alignments based on entity descriptions [13], to learn alignments from dialogues framed in interaction protocols [14], [18], or to correct alignments until no error remains [17][3] and to start with no alignment [2]. Each study provides new insights and opens perspectives.

We adapt this experimental strategy to knowledge representation [3]. Agents use their, shared or private, knowledge to play games and, in case of failure, they use adaptation operators to modify this knowledge. We monitor the evolution of agent knowledge with respect to their ability to perform the game (success rate) and with respect to the properties satisfied by the resulting knowledge itself. Such properties may, for instance, be:

- Agents converge to a common knowledge representation (a convergence property).
- Agents converge towards different but compatible (logically consistent) knowledge (a logical epistemic property), or towards closer knowledge (a metric epistemic property).
- That under the threat of a changing environment, agents that have operators that preserve diverse knowledge recover faster from the changes than those that have operators that converge towards a single representation (a differential property under environment change).

Our goal is to determine which operators are suitable for achieving desired properties in the context of a particular game.

4. Highlights of the Year

4.1. Highlights of the Year

- We published our work on relational concept analysis applied to link key extraction in *Discrete applied mathematics* [5].
- Jérôme Euzenat was invited to deliver a keynote talk at the International semantic web conference (ISWC), in Aukland (NZ). The title of the talk was a call to brains: *For knowledge!*
- The teams leads the *Knowledge communication and evolution* chair of the Multidisciplinary Institute of Artificial Intelligence awarded in Grenoble.

5. New Software and Platforms

5.1. Lazylav

Lazy lavender

KEYWORDS: Reproducibility - Multi-agent - Simulation

SCIENTIFIC DESCRIPTION: Lazy lavender aims at supporting mOeX's research on simulating knowledge evolution. It is not a general purpose simulator. However, it features some methodological innovations in term of facilitating publication, recording, and replaying of experiments.

FUNCTIONAL DESCRIPTION: Lazy Lavender is a simulation environment for cultural knowledge evolution, i.e. running randomised experiments with agent adjusting their knowledge while attempting to communicate. It can generate detailed report and data from the experiments and directions to repeat them.

NEWS OF THE YEAR: In 2019, we implemented facilities for dealing with population of agents and designed several synchronisation approaches. This led to seriously refactor the code.

- Participant: Jérôme Euzenat
- Contact: Jérôme Euzenat
- Publications: Crafting ontology alignments from scratch through agent communication - Interaction-based ontology alignment repair with expansion and relaxation - First experiments in cultural alignment repair (extended version)
- URL: http://lazylav.gforge.inria.fr

5.2. Alignment API

KEYWORDS: Ontologies - Alignment - Ontology engineering - Knowledge representation

SCIENTIFIC DESCRIPTION: The api itself is a Java description of tools for accessing the common format. It defines five main interfaces (OntologyNetwork, Alignment, Cell, Relation and Evaluator).

We provide an implementation for this api which can be used for producing transformations, rules or bridge axioms independently from the algorithm that produced the alignment. The proposed implementation features: - a base implementation of the interfaces with all useful facilities, - a library of sample matchers, - a library of renderers (XSLT, RDF, SKOS, SWRL, OWL, C-OWL, SPARQL), - a library of evaluators (various generalisation of precision/recall, precision/recall graphs), - a flexible test generation framework that allows for generating evaluation data sets, - a library of wrappers for several ontology APIs , - a parser for the format.

To instanciate the API , it is sufficient to refine the base implementation by implementing the align() method. Doing so, the new implementation will benefit from all the services already implemented in the base implementation.

FUNCTIONAL DESCRIPTION: Using ontologies is the privileged way to achieve interoperability among heterogeneous systems within the Semantic web. However, as the ontologies underlying two systems are not necessarily compatible, they may in turn need to be reconciled. Ontology reconciliation requires most of the time to find the correspondences between entities (e.g. classes, objects, properties) occurring in the ontologies. We call a set of such correspondences an alignment.

NEWS OF THE YEAR: Link keys are fully supported by the EDOAL language. In particular it can transform them into SPARQL queries.

- Participants: Armen Inants, Chan Le Duc, Jérôme David, Jérôme Euzenat, Jérôme Pierson, Luz Maria Priego-Roche and Nicolas Guillouet
- Contact: Jérôme Euzenat
- Publications: An API for ontology alignment - The Alignment API 4.0
- URL: http://alignapi.gforge.inria.fr/

6. New Results

6.1. Cultural knowledge evolution

Our cultural knowledge evolution work currently focusses on alignment evolution.

Agents may use ontology alignments to communicate when they represent knowledge with different ontologies: alignments help reclassifying objects from one ontology to the other. Such alignments may be provided by dedicated algorithms [4], but their accuracy is far from satisfying. Yet agents have to proceed. They can take advantage of their experience in order to evolve alignments: upon communication failure, they will adapt the alignments to avoid reproducing the same mistake.

We performed such repair experiments [3] and revealed that, by playing simple interaction games, agents can effectively repair random networks of ontologies or even create new alignments.

6.1.1. Modelling in dynamic epistemic logic

Participants: Manuel Atencia, Jérôme Euzenat, Line Van Den Berg [Correspondent].

We explored how closely these operators resemble logical dynamics. We developed a variant of Dynamic Epistemic Logic to capture the dynamics of the cultural alignment repair game. The ontologies are modelled as knowledge and alignments as beliefs in a variant of plausibility-based dynamic epistemic logic. The dynamics of the game is achieved through (public) announcement of the game issue and the adaptation operators are defined through conservative upgrades, i.e. modalities that transform models by reordering world-plausibility. This allowed us to formally establish some limitations and redundancy of the operators [9]. More precisely, for a complete logical reasoner, the operators are redundant and some may be inconsistent with the agent knowledge.

These results hold for one agent in the game but not necessarily for the other that may not know the classes by which the alignment is repaired, nor the relations between them. The former can be dealt with by declaring that agents are aware of the signature of both ontologies (public signature assumption) but this does not allow ontologies to evolve. We are currently investigating partial semantics as a more dynamic alternative solution to this problem.

This work is part of the PhD thesis of Line van den Berg.

6.1.2. Populations

Participants: Manuel Atencia, Fatima Danash, Jérôme Euzenat [Correspondent].

We started taking the population standpoint on experimental cultural evolution. For that purpose we introduced the concept of population within the experiments. So far, a population is characterised as a set of agents sharing the same ontology. Such agents play the same alignment repair games as before with agents of other populations.

The notion of population enables to experiment with different transmission mechanisms found in cultural evolution: vertical transmission, in which culture spreads, like genes, from parents to sibblings, and horizontal transmission, in which it spreads among all members of a population. We implemented explicit horizontal transmission through a synchronisation procedure in which, at a given interval, agents of the same population exchange their knowledge, i.e. alignments.

6.1.3. Link with interactor-replicator

Participant: Jérôme Euzenat [Correspondent].

Cultural evolution may be studied at a 'macro' level, inspired from population dynamics, or at a 'micro' level, inspired from genetics. The replicator-interactor model generalises the genotype-phenotype distinction of genetic evolution. We considered how it can be applied to cultural knowledge evolution experiments [8]. More specifically, we consider knowledge as the replicator and the behaviour it induces as the interactor. We showed that this requires to address problems concerning transmission. We discussed the introduction of horizontal transmission within the replicator-interactor model and/or differential reproduction within cultural evolution experiments.

6.1.4. Experiment reproducibility

Participants: Jimmy Avae, Robin Couret, Jérôme Euzenat [Correspondent].

Experiments are described and performed in our *Lazy lavender* platform which offers scripts to specify, run, and analyse experiments. This year, we investigated expressing experiment descriptions, i.e. design, results and analysis, in RDF. This facilitates the search of experiments based on structured queries that can be expressed in SPARQL: "which experiments have been performed but not analysed?", "which experiments are derived from another specific experiment?", "which hypotheses have not been confirmed since a precise release?", "which experiments test F-measure increase?". This also suggest a better organisation of our experiment reports.

6.2. Link keys

Link keys (§3.2) are explored following two directions:

- Extracting link keys;
- Reasoning with link keys.

6.2.1. Link key extraction with relational concept analysis

Participants: Manuel Atencia, Jérôme David [Correspondent], Jérôme Euzenat.

We first described our extraction approach [1] in the framework of formal context analysis (FCA, [20]). We recently showed that link keys extracted by formal concept analysis are equivalent to an extension of those which were extracted by our former algorithm [15]. We also used pattern structures, an extension of FCA with ordered structures, to reformulate this problem [6].

Furthermore, we used relational concept analysis (RCA, [22]), an extension of FCA taking relations between concepts into account. We showed that it is possible to encode the link key extraction problem in RCA to extract the optimal link keys even in the presence of cyclic dependencies [5]. Moreover, the proposed process does not require information about the alignments between the ontologies to find out from which pairs of classes to extract link keys.

We implemented these methods and evaluated them by reproducing the experiments made in previous studies. This shows that the method extracts the expected results as well as (also expected) scalability issues.

6.2.2. Combining link keys

Participants: Manuel Atencia, Alice Caporali, Jérôme David [Correspondent], Jérôme Euzenat, Basile Legal.

For certain data sets, it may be necessary to use several link keys, even on the same pair of classes, for retrieving a more complete link set. We introduced operators to combine link keys over the same pair of classes, investigated their relations and extended measures to evaluate their quality.

We specifically proposed strategies to extract disjunctions from RDF data and apply existing quality measures to evaluate them. We experimented with these strategies showing their benefits [7].

6.2.3. Tableau method for $\mathcal{ALC}$+Link key reasoning

Participants: Manuel Atencia [Correspondent], Jérôme Euzenat, Khadija Jradeh.

Link keys can also be thought of as axioms in a description logic. As such, they can contribute to infer ABox axioms, such as links, terminological axioms, or other link keys. This has important practical applications, such as link key inference, link key consistency and link key redundancy checking. Yet, no reasoning support existed for link keys.

We previously extended the tableau method designed for the $\mathcal{ALC}$ description logic to support reasoning with link keys in $\mathcal{ALC}$. We showed how this extension enables combining link keys with classical terminological reasoning with and without ABox and TBox and generating non-trivial link keys. We further extended the method and have proven that this extended method terminates, is sound, complete, and that its complexity is 2EXPTIME [11].

This work is part of the PhD thesis of Khadija Jradeh, co-supervised with Chan Le Duc (LIASD).

7. Partnerships and Cooperations

7.1. National Initiatives

7.1.1. ANR Elker

Program: ANR-PRC

Project acronym: ELKER

Project title: Extending link keys: extraction and reasoning

Web site: https://project.inria.fr/elker/

Duration: October 2017 - September 2021

Coordinator: LIG/Manuel Atencia

Participants: Manuel Atencia Arcas, Jérôme David, Jérôme Euzenat

Other partners: Inria Lorraine, Université de Vincennes+Université Paris 13

Abstract: The goal of ELKER is to extend the foundations and algorithms of link keys (see §3.2) in two complementary ways: extracting link keys automatically from datasets and reasoning with link keys.

7.1.2. PEPS RegleX-LD

Program: Projets Exploratoires Premier Soutien (CNRS, INS2I)

Project acronym: REGLEX-LD

Project title: Découverte de règles expressives de correspondances complexes et de liage de données

Duration: January 2019 – December 2019

Coordinator: IRIT/Cássia Trojahn

Participants: Manuel Atencia Arcas, Jérôme David, Jérôme Euzenat

Other partners: IRIT Toulouse, INRA Paris, LRI Orsay

Abstract: RegleX-LD aims at discovering expressive ontology correspondences and data interlinking patterns using unsupervised or weakly supervised methods.

7.2. International Research Visitors

7.2.1. Visits of International Scientists

7.2.1.1. Internships

- Nacira Abbas (U. Lorraine) visited mOeX between 2019-02-04 and 2019-02-15 in the framework of the Elker project, working on link keys extraction with formal concept analysis.
- Hiba Belhadi, PhD student at Université des Sciences et de la Technologie Houari Boumediene (UTHB), Algiers, visited mOeX between 2019-10-15 and 2019-11-15 to work on selecting and matching properties for data interlinking.

8. Dissemination

8.1. Promoting Scientific Activities

8.1.1. Scientific Events: Organisation

8.1.1.1. Member of the Organizing Committees

- Jérôme Euzenat was organiser of the 2nd Workshop on Interaction-Based Knowledge Sharing (WINKS) of the 5th Joint Ontology Workshop (JOWO), Graz (AT), 2019 (with Adrian Kemo, Dagmar Gromann, Ernesto Jiménez Ruiz, Marco Schorlemmer and Valentina Tamma) [10]
- Jérôme Euzenat had been organiser of the 14th Ontology matching workshop of the 19th ISWC, Auckland (NZ), 2019 (with Pavel Shvaiko, Ernesto Jiménez Ruiz, Cássia Trojahn dos Santos and Oktie Hassanzadeh)

8.1.2. Scientific Events: Selection

8.1.2.1. Member of the Conference Program Committees

- Manuel Atencia, Jérôme David and Jérôme Euzenat have been programme committee members of the "International Joint Conference on Artificial Intelligence (IJCAI)".
- Manuel Atencia, Jérôme David and Jérôme Euzenat have been programme committee member of the "Web Conference (WWW)".
- Manuel Atencia, Jérôme David and Jérôme Euzenat have been programme committee members of the "International semantic web conference (ISWC)".
- Jérôme Euzenat has been programme committee member of the "International Conference on Conceptual Structures (ICCS)".
- Jérôme Euzenat has been programme committee member of the "International conference on semantic systems (Semantics)".

- Jérôme Euzenat has been programme committee member of the "Journées Françaises d'intelligence artificielle fondamentale (JIAF)".
- Manuel Atencia and Jérôme David have been programme committee members of the "Extraction et Gestion des connaissances (EGC)".

8.1.3. Journal

8.1.3.1. Member of the Editorial Boards

- Jérôme Euzenat is member of the editorial board of *Journal of web semantics* (area editor), *Journal on data semantics* and the *Semantic web journal*.

8.1.3.2. Reviewer - Reviewing Activities

- Manuel Atencia had been reviewer for *Journal of web semantics*.
- Jérôme David had been reviewer for *Journal of web semantics*.
- Jérôme Euzenat had been reviewer for *Knowledge engineering reviews*.

8.1.4. Invited Talks

- "For knowledge", ISWC keynote speech, Auckland (NZ), 2019-10-29 (Jérôme Euzenat)

8.1.5. Leadership within the Scientific Community

- Jérôme Euzenat is member of the scientific council of the CNRS GDR on Formal and Algorithmic Aspects of Artificial intelligence.
- Jérôme Euzenat is EurAI fellow.
- Jérôme David is member of the board of the Extraction and gestion des connaissances (Knowledge extraction and management) conference series.

8.1.6. Scientific Expertise

- Jérôme Euzenat had been member of the HCERES visiting committee for the CRIL research laboratory.
- Jérôme Euzenat had been member of the recruitment committee of Université Grenoble Alpes for the associate professor position 27MCF330, 2019.

8.2. Teaching - Supervision - Juries

8.2.1. Teaching

8.2.1.1. Responsibilities

- Jérôme David is coordinator of the Master "Mathematiques et informatiques appliquées aux sciences humaines et sociales" (Univ. Grenoble Alpes);
- Manuel Atencia is co-responsible of the 2nd year of Master "Mathematiques et informatiques appliquées aux sciences humaines et sociales" (Univ. Grenoble Alpes);
- Manuel Atencia is coordinator of the "Web, Informatique et Connaissance" option of the master M2 "Mathematicques et informatiques appliquées aux sciences humaines et sociales" (Univ. Grenoble Alpes);

8.2.1.2. Lectures

- Licence: Jérôme David, Algorithmique et programmation par objets, 70h/y, L2 MIASHS, UGA, France
- Licence: Jérôme David, Système, L3 MIASHS, 18h/y, UGA, France
- Licence: Manuel Atencia, Introduction aux technologies du Web, 60h/y, L3 MIASHS, UGA, France
- Master: Jérôme David, Programmation Java 2, 30h/y, M1 MIASHS, UGA, France

- Master: Jérôme David, JavaEE, 30h/y, M2 MIASHS, UGA, France
- Master: Jérôme David, Développement Web Mobile, 30h/y, M2 MIASHS, UGA, France
- Master: Jérôme David, Web sémantique, 3h/y, M2 MIASHS, UGA, France
- Master: Manuel Atencia, Formats de données du web, 30h/y, M1 MIASHS, UGA, France
- Master: Manuel Atencia, Introduction à la programmation web, 30h/y, M1 MIASHS, UGA, France
- Master: Manuel Atencia, Intelligence artificielle, 7.5h/y, M1 MIASHS, UGA, France
- Master: Manuel Atencia, Web sémantique, 27h/y, M2 MIASHS, UGA, France
- Master: Manuel Atencia, Semantic web: from XML to OWL, 22.5h/y, M2R MoSIG, UGA, France
- Master: Jérôme David, Stage de programmation, 10h/y, M2 MIASHS, UGA, France

8.2.2. Supervision

- Nacira Abbas, "Link key extraction and relational concept analysis", in progress since 2018-10-01 (Jérôme David and Amedeo Napoli)
- Khadija Jradeh, "Reasoning with link keys", in progress since 2018-10-01 (Manuel Atencia and Chan Le Duc)
- Line van den Berg, "Knowledge Evolution in Agent Populations", in progress since 2018-10-01 (Manuel Atencia and Jérôme Euzenat)
- Yasser Bourahla, "Evolving ontologies through communication", in progress since 2019-10-01 (Manuel Atencia and Jérôme Euzenat)

8.2.3. Juries

- Jérôme Euzenat had been reviewer and panel chair of the computer science PhD of Élodie Thiéblin (Université Toulouse 3 Paul Sabatier) "Automatic generation of complex ontology alignments" supervised by Ollivier Haemmerlé and Cássia Trojahn, 2019
- Jérôme Euzenat had been member of the computer science habilitation (HDR) panel of Cássia Trojahn (Université Toulouse 2 Jean Jaurès) "Towards ontology matching maturity: contributions to complex, holistic and foundational ontology matching", 2019

8.3. Popularization

8.3.1. Interventions

- Présentation "L'intelligence artificielle en perspective", Université Inter-Âges du Dauphiné (UIAD), Grenoble (FR), 2019-03-06 (Jérôme Euzenat)
- Introduction of the *Class?* game to a fourth graders (CM1-CM2) class, Montbonnot (FR), 2019-06-25 (Line van den Berg and Jérôme Euzenat)
- Introduction of the *Class?* game to a tenth graders (2^{nd} MathC2+) group, Montbonnot (FR), 2019-06-25 (Line van den Berg and Jérôme Euzenat)
- Introduction of the *Class?* game to seventh and eighth graders (5^{e} et 4^{e}) classes within the Fête de la science (Science fair), Montbonnot (FR), 2019-10-10 (Line van den Berg and Jérôme Euzenat)
- Introduction of the *Class?* game to general public within the Fête de la science (Science fair), Montbonnot (FR), 2019-10-12 (Line van den Berg and Jérôme Euzenat)
- Presentation of the *Class?* game to the meeting of the Société Francophone de Classification, Nancy (FR), 2019-09-03–04 (Jérôme Euzenat)

8.3.2. Creation of media or tools for science outreach

Class? We are developing mediation material for explaining to the general public what knowledge representation is and how it may evolve. Its main goal is to show children that the same individuals may be classified in different and evolving ways and that it is possible to communicate such classifications without expressing them. For that purpose, we have designed a card game called *Class?* [1] which allows players to guess the hidden ontology of another player. It has been presented to school classes from year 5 of primary school (fourth graders) to year 11 (tenth graders), albeit shows features of interest for a wider audience.

[1] https://moex.inria.fr/mediation/class/

9. Bibliography

Major publications by the team in recent years

[1] M. ATENCIA, J. DAVID, J. EUZENAT. *Data interlinking through robust linkkey extraction*, in "Proc. 21st european conference on artificial intelligence (ECAI), Praha (CZ)", Amsterdam (NL), T. SCHAUB, G. FRIEDRICH, B. O'SULLIVAN (editors), IOS press, 2014, pp. 15-20, ftp://ftp.inrialpes.fr/pub/exmo/publications/atencia2014b.pdf

[2] J. EUZENAT. *Crafting ontology alignments from scratch through agent communication*, in "PRIMA 2017: Principles and Practice of Multi-Agent Systems", Nice, France, B. AN, A. BAZZAN, J. LEITE, S. VILLATA, L. VAN DER TORRE (editors), Springer Verlag, 2017, pp. 245-262

[3] J. EUZENAT. *Interaction-based ontology alignment repair with expansion and relaxation*, in "Proc. 26th International Joint Conference on Artificial Intelligence (IJCAI), Melbourne (VIC AU)", 2017, pp. 185–191

[4] J. EUZENAT, P. SHVAIKO. *Ontology matching*, 2nd, Springer-Verlag, Heidelberg (DE), 2013, http://book.ontologymatching.org

Publications of the year

Articles in International Peer-Reviewed Journals

[5] M. ATENCIA, J. DAVID, J. EUZENAT, A. NAPOLI, J. VIZZINI. *Link key candidate extraction with relational concept analysis*, in "Discrete Applied Mathematics", 2019, pp. 1-19 [*DOI :* 10.1016/J.DAM.2019.02.012], https://hal.archives-ouvertes.fr/hal-02196757

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