RESEARCH CENTRE

Inria Center at Université Grenoble Alpes

IN PARTNERSHIP WITH:

Université de Grenoble Alpes

2022

ACTIVITY REPORT

Project-Team

MOEX

Evolving Knowledge

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

DOMAIN

Perception, Cognition and Interaction

THEME

Data and Knowledge Representation and Processing

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Project-Team MOEX

Creation of the Project-Team: 2017 November 01

Keywords

Computer sciences and digital sciences

A3.2. – Knowledge

A3.2.1. – Knowledge bases

A3.2.2. – Knowledge extraction, cleaning

A3.2.4. – Semantic Web

A3.2.5. – Ontologies

A3.2.6. – Linked data

A6.1.3. – Discrete Modeling (multi-agent, people centered)

A7.2. – Logic in Computer Science

A9. – Artificial intelligence

A9.1. – Knowledge

A9.9. – Distributed AI, Multi-agent

Other research topics and application domains

B8.5. – Smart society

B9. – Society and Knowledge

B9.5.1. – Computer science

B9.7.2. – Open data

B9.8. – Reproducibility

1 Team members, visitors, external collaborators

Research Scientist

- Jerome Euzenat [Team leader, INRIA, Senior Researcher, HDR]

Faculty Members

- Manuel Atencia [UGA, Associate Professor]
- Jérôme David [UGA, Associate Professor]

Post-Doctoral Fellow

- Helga Lendrin [INRIA, from Oct 2022]

PhD Students

- Yasser Bourahla [UGA, from Oct 2022]
- Yasser Bourahla [INRIA, until Sep 2022]
- Khadija Jradeh [UGA, until Apr 2022]
- Andrea Kalaitzakis [UGA]

Technical Staff

- Jose Luis Aguirre Cervantes [UGA, Engineer, from Feb 2022 until May 2022]

Interns and Apprentices

- Esdras Assikidana [UGA, Intern, from Feb 2022 until Jun 2022, TER M1 MoSIG]
- Lola Lamirand [UGA, from Jun 2022]
- Nathan Lufuluabo [UGA, Intern, from Jun 2022 until Jun 2022]
- Meryem Naciri [UGA, Intern, from Feb 2022, M2, ENSIAS, Rabat]
- Djoser Simeu [UGA, from Sep 2022]

Administrative Assistant

- Julia Di Toro [INRIA]

2 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.) [5].

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 [5, 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 [23]. It applies a generalised 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 [20]: 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 [25, 24]. 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 [4], to create alignments based on entity descriptions [18], to learn alignments from dialogues framed in interaction protocols [19, 22], or to correct alignments until no error remains [21][4] and to start with no alignment [3]. Each study provides new insights and opens perspectives.

We adapt this experimental strategy to knowledge representation [4]. 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.

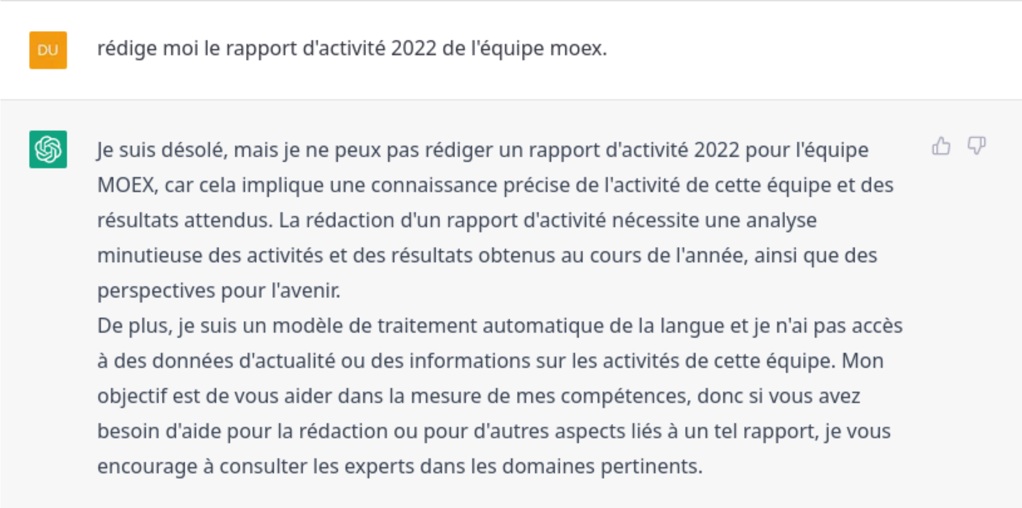
4 Application domains

Our work on data interlinking aims at application to linked data offered in RDF on the web. It has found applications in thesaurus and bibliographical data interlinking (see previous years' report).

mOeX's work on cultural knowledge evolution is not directly applied and rather aims at isolating general principles of knowledge evolution. However, we foresee its potential impact in the long term in fields such as smart cities, the internet of things or social robotics in which the knowledge acquired by autonomous agents will have to be adapted to changing situations.

5 Highlights of the year

In 2022, ChatGPT was all the rage. We thus tried to challenge it.



Unfortunately, AI is not yet able to produce this activity report. So, this year again, what you will read had to be written by a human being.

6 New software and platforms

6.1 New software

6.1.1 Lazylav

Name: 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.

Release Contributions: Lazy is continuously evolving and do not feature stable releases.

Instead, use git hashes to determine which version is used in a simulation.

News of the Year: In 2022, two threads were followed: (a) concerning alignment repair, the addition of disruptive events and specific parameters to control diversity, (b) increased parameters to control the behaviour of specialised agents (number of tasks played, size of ontologies, choice of the other player, task preferences).

URL: https://gitlab.inria.fr/moex/lazylav/

Publications: hal-03426130, hal-01661140, hal-01661139, hal-01180916, hal-03939919, hal-03905183

Contact: Jerome Euzenat

Participants: Jerome Euzenat, Yasser Bourahla, Iris Lohja, Fatme Danash, Irina Dragoste, Andrea Kalaitzakis

6.1.2 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.

The API implementation provides an extended language for expressive alignments (EDOAL). EDOAL supports many types of restrictions inspired from description logics as well as link keys. It is fully supported for parsing and serialising in XML. It also provide other serialisers, to OWL and SPARQL queries in particular.

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.

Release Contributions: See release notes.

This is the last release made from gforge svn repository. After it, the Alignment API is hosted by gitlab and versioned with git. It may well be the last formal release, clone from the repo instead.

The Alignment API compiles in Java 11 (jars are still compiled in Java 8).

URL: https://moex.gitlabpages.inria.fr/alignapi/

Publications: hal-00825931, hal-00781018

Contact: Jerome Euzenat

Participants: Armen Inants, Chan Le Duc, Jérôme David, Jerome Euzenat, Jérôme Pierson, Luz Maria Priego-Roche, Nicolas Guillouet

6.1.3 LinkEx

Keywords: LOD - Linked open data, Data interlinking, Formal concept analysis

Functional Description: LinkEx implements link key candidate extraction with our initial algorithms, formal concept analysis or pattern structures. It can extract link key expressions with inverse and composed properties and generate compound link keys. Extracted link key expressions may be evaluated using various measures, including our discriminability and coverage. It can also evaluate them according to an input link sample. The set of candidates can be rendered within the Alignment API's EDOAL language or in dot.

News of the Year: We are now able to compute the owl:sameAs closure of a set of links (and also the partition of instances). EDOAL rendering of link keys has been improved: give the pair of classes attached with the link key, render link keys with property composition and inverse.

URL: `https://gitlab.inria.fr/moex/linkex`

Publications: hal-02168775, hal-01179166

Author: Jérôme David

Contact: Jérôme David

7 New results

7.1 Cultural knowledge evolution

2022 saw the continuation of our work on experimental cultural knowledge evolution through studying the impact of diversity of knowledge and of agent preference on knowledge. Concerning link keys the work on reasoning in description logic with link keys led to the PhD thesis of Khadija Jradeh; the work on extracting them was pursued in the perspective of increasing the quality of link keys.

7.1.1 Knowledge transmission across agent generations

Participants: Manuel Atencia, Yasser Bourahla *(Correspondent)*, Jérôme Euzenat.

Last year, we showed that vertical transmission improves on horizontal transmission even without drastic selection and oriented learning. We also showed that horizontal transmission is able to compensate for the lack of parent selection if it is maintained for long enough [7, 10, 11]. In 2022, we also confirmed that that this setting was able to preserve knowledge diversity, although it decreases.

This work is part of the PhD thesis of Yasser Bourahla.

7.1.2 Measuring and controlling knowledge diversity

Participants: Yasser Bourahla, Jérôme David, Jérôme Euzenat *(Correspondent)*, Meryem Naciri.

Assessing knowledge diversity may be useful for many purposes. In particular, it is necessary to measure diversity in order to understand how it arises or is preserved (see §7.1.1). It is also necessary to control it in order to measure its effects. We have considered measuring knowledge diversity using two components: (a) a diversity measure taking advantage of (b) a knowledge difference measure [8]. We have proposed general principles for such components and compared various candidates. The most satisfycing solutions are entropy-based measures. We designed algorithms using these measures to generate populations of agents with controlled levels of knowledge diversity.

7.1.3 Pluripotent agents

Participants: Jérôme Euzenat, Andrea Kalaitzakis *(Correspondent)*.

We introduced multi-tasking agents that interact over a limited set of tasks. Unintuitively, our experiments demonstrate that multi-task agents are not necessarily less accurate than specialised one. We constrained agent memory size to be limited, in order to avoid multi-tasking agents to learn all tasks in the long term. On the one hand, when agents have unlimited memory, generalist agents are always more accurate than specialist agents on all tasks. On the other hand, when agents have limited memory, results suggest that the goals of maximising task specific accuracy and achieving consensus are mutually exclusive. Agents can either specialise in detriment of their interoperability, or learn to agree but fail to specialise.

This work is part of the PhD thesis of Andreas Kalaitzakis.

7.1.4 Experiment reproducibility

Participants: Jose Luis Aguirre Cervantes, Yasser Bourahla, Jérôme Euzenat *(Correspondent)*.

We have pursued our effort to document the repurposing of our experiments as Jupyter notebooks (https://sake.re). Some neglected benefits of semantically describing experiments provide more arguments in favour of scientific knowledge graphs [9]. Beyond being searchable through flat metadata, a knowledge graph of experiment descriptions may be able to provide answers to scientific and methodological questions. This includes identifying non experimented conditions or retrieving specific techniques used in experiments. In turn, this is useful for researchers as this information can be used for repurposing experiments, checking claimed results or performing meta-analyses.

7.1.5 A social science and the humanities approach to cultural knowledge evolution

Participants: Helga Lendrin *(Correspondent)*, Jérôme Euzenat.

We are designing experiments with human learners to test the hypothesis that the medium used for knowledge transmission has an effect on its acquisition and evolution. As a corollary, we want to assess the impact of physical presence, as a medium for knowledge transmission, on knowledge evolution. In other words, is the hybrid mode of teaching closer to the written modality of knowledge transmission or to the face-to-face classroom modality? For that purpose, we are investigating the possible use of the *Class?* game in the classroom.

7.2 Link keys

The link key exploration is continued following two directions (§3.2):

- Extracting link keys;
- Reasoning with link keys.

7.2.1 Strategies for identifying high-quality link keys

Participants: Jérôme David *(Correspondent)*.

We have studied and evaluated the redundancy of link keys based on the fact that owl:sameAs is an equivalence relation. To that extent we use the formalism of Partition Pattern Structures (pps) to detect such redundancy [6]. In the pps concept lattice, every concept has an extent representing a link key candidate and an intent representing a partition of instances into sets of equivalent instances. Experiments showed two main results. First, redundancy of link keys is not so significant in real-world datasets. Nevertheless, the link key discovery approach based on pps returns a reduced number of non redundant link key candidates.

This work is part of the PhD thesis of Nacira Abbas, co-supervised by Amedeo Napoli (LORIA).

7.2.2 An effective algorithm for reasoning with link keys

Participants: Manuel Atencia, Khadija Jradeh *(Correspondent)*.

Link keys can be thought of as axioms in a description logic. It is thus possible to reason with link keys in combination with ontologies and alignments. In 2022, we have defined a compressed tableau for reasoning in the description logic $\mathscr{ALC}$ extended with link keys and inverse roles. This provides a solid basis for designing a worst-case optimal algorithm for reasoning in the description logic $\mathscr{ALCI}$ extended with link keys. We have also proposed and evaluated different strategies to integrate reasoning with link keys in the data interlinking pipeline.

This work was the final part the PhD thesis of Khadija Jradeh [14], co-supervised by Chan Le Duc (LIMICS).

8 Partnerships and cooperations

8.1 European initiatives

8.1.1 Horizon Europe

Tailor mOeX participates in the Tailor network, especially in work package 6 “Social AI: learning and reasoning in social contexts”:

Participants: Jérôme Euzenat *(Correspondent)*, Yasser Bourahla, Andreas Kalaitzakis.

Program: H2020 ICT-48

Title: Foundations of Trustworthy AI integating Learning, Optimisation and Reasoning

Partner Institution(s):
- Linköping University, Sweden (coordinator)
- Université Grenoble Alpes, France
- INRIA, France
- many others

Duration: 2020–2024

Web site: https://tailor-network.eu/

Abstract: The purpose of TAILOR is to build the capacity of providing the scientific foundations for Trustworthy AI in Europe by developing a network of research excellence centres leveraging and combining learning, optimization and reasoning.

8.2 National initiatives

8.2.1 ELKER

Participants: Manuel Atencia *(Correspondent)*, Jérôme David, Jérôme Euzenat, Khadija Jradeh.

mOeX coordinates the ELKER project:

Program: ANR-PRC

Title: Extending link keys: extraction and reasoning

Partner Institution(s):
- Université Grenoble Alpes (coordinator)
- INRIA Nancy Lorraine (Orpailleur)
- Université Paris 13

Duration: October 2017–March 2023

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

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.

8.2.2 MIAI

Participants: Manuel Atencia, Jérôme David, Jérôme Euzenat *(Correspondent)*, Yasser Bourahla, Andreas Kalaitzakis.

mOeX holds the MIAI Knowledge communication and evolution chair

Program: ANR-3IA

Title: Multidisciplinary institute in artificial intelligence

Partner Institution(s):
- Université Grenoble Alpes (coordinator)

Duration: July 2019–December 2023

Web site: https://miai.univ-grenoble-alpes.fr

Abstract: The MIAI Knowledge communication and evolution chair aims at understanding and developing mechanisms for seamlessly improving knowledge (see §3.3). It studies the evolution of knowledge in a society of people and AI systems by applying evolution theory to knowledge representation.

9 Dissemination

Participants: Jérôme David, Jérôme Euzenat, Helga Lendrin.

9.1 Promoting scientific activities

9.1.1 Scientific events: organisation

Member of the organizing committees

- Jérôme Euzenat had been organiser of the 17th Ontology matching workshop of the 22th ISWC, held online, 2022 (with Pavel Shvaiko, Ernesto Jiménez Ruiz, Cássia Trojahn dos Santos and Oktie Hassanzadeh) [13]

9.1.2 Scientific events: selection

Conference spetial issue editor

- Jérôme Euzenat, with Isabelle Bloch, Jérôme Lang and François Schwarzentruber have been invited editors of the special issue of "Revue ouverte d'intelligence artificielle" dedicated to selected papers of the French national artificial intelligence conferences 2018, 2019 and 2020 [12, 17]

Member of conference program committees

- Jérôme Euzenat has been programme committee member of the "International Joint Conference on Artificial Intelligence (IJCAI)-European Conference on Artificial Intelligence (ECAI)".
- Jérôme Euzenat has been programme committee member of the "International Conference on Autonomous Agents and Multi-Agent Systems (AAMAS)".
- Jérôme David has been programme committee member of the "European semantic web conference (ESWC)".
- Jérôme David has been programme committee member of "Extraction et gestion des connaissances (EGC)".
- Jérôme David has been programme committee member of "Ingénierie des connaissances (IC)".
- Jérôme Euzenat has been programme committee member of the "Journées Françaises d'intelligence artificielle fondamentale (JIAF)".

9.1.3 Journal

Member of the editorial boards

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

Reviewer - reviewing activities

- Jérôme Euzenat had been reviewer for *Applied ontologies*.

9.1.4 Invited talks

- Jérôme David gave an invited talk to the Decade workshop (DEcouverte de Connaissances et Apprentissage dans les Données graphEs), Saint-Étienne (FR), 2022-06-28, on "Selection of representative subsets of link key candidates"
- Helga Lendrin talked about the industrialisation process of higher education in sub-Saharan Africaat at University of Paris 1 Master 2 seminar on "digital experimentation in Africa", 2022-12-02
- Jérôme Euzenat has been invited to the "Belief revision, argumentation and ontologies (BRAOn)" workshop, Madeira (PT), 2022-03-27-31
- Jérôme Euzenat gave an invited talk to the International Collaborative Workshop of Ruhr Universität Bochum-Université Grenoble Alpes-University of Tsukuba, online, 2022-12-15, on "Artificial cultural knowledge evolution: agents that share knowledge".

9.1.5 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.

9.1.6 Research administration

- Jérôme Euzenat is member of the COS (Scientific Orientation Committee) of INRIA Grenoble Rhône-Alpes
- Jérôme David is member of the "Commission du développement technologique" of INRIA Grenoble Rhône-Alpes
- Jérôme David is member of the LIG laboratory council

9.2 Teaching - Supervision - Juries

9.2.1 Teaching

Responsibilities

- Jérôme David is coordinator of the Master “Mathematiques et informatiques appliquées aux sciences humaines et sociales” (Univ. Grenoble Alpes);

Lectures

- Licence: Jérôme David and Jérôme Euzenat, Programmation Logique, L1 MIASHS, 24h/y, UGA, France
- Licence: Jérôme David, Algorithmique et programmation par objets, 70h/y, L2 MIASHS, UGA, France
- Licence: Jérôme David, Système, L3 MIASHS, 18h/y, UGA, France
- Master: Jérôme David, Systèmes d’exploitation, M1 DCISS, 27h/y, UGA, France
- Master: Yasser Bourahla, AI for complex systems, 42h/y, M1 MIASHS, UGA, France
- Master: Yasser Bourahla, Formats de données du web, 42h/y, M1 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, Web sémantique, 3h/y, M2 MIASHS, UGA, France
- Master: Jérôme David, Stage de programmation, 10h/y, M2 MIASHS, UGA, France
- Master: Jérôme Euzenat, Semantics of distributed knowledge, 27h/y, M2R MoSIG, UGA, France

9.2.2 Supervision

- Nacira Abbas, "Link key extraction and relational concept analysis", in progress since 2018-10-01 (Jérôme David and Amedeo Napoli)
- Khadija Jradeh, "Optimised tableau algorithms for reasoning in the description logic ALC extended with link keys" [14], defended on 2022-07-12 (Manuel Atencia and Chan Le Duc)
- Yasser Bourahla, "Evolving ontologies through communication", in progress since 2019-10-01 (Manuel Atencia and Jérôme Euzenat)
- Andreas Kalaitzakis, "Effects of collaboration and specialisation on agent knowledge evolution", in progress since 2020-10-01 (Jérôme Euzenat)

9.3 Popularization

9.3.1 Articles and contents

- We have implemented the first part of the *Class?* game as a computer game (https://gitlab.inria.fr/moex/classapp).
- We have completed the design and published our Small *Class?* game book [16] which offers a progressive curriculum investigating the ins-and-outs of the game.

9.3.2 Interventions

- Introduction of the *Class?* game to a tenth graders (2nd MathC2+) group, Montbonnot (FR), 2022-06-27.
- Introduction by all members of mOeX of the *Class?* game to ninth graders within the Fête de la science (Science fair), Saint-Martin d'Hères (FR), 2022-10-13

10 Scientific production

10.1 Major publications

[1] M. Atencia, J. David and J. Euzenat. 'On the relation between keys and link keys for data interlinking'. In: *Semantic Web – Interoperability, Usability, Applicability* 12.4 (2021), pp. 547–567. DOI: 10.3233/SW-200414. URL: https://hal.science/hal-03426150.

[2] Y. Bourahla, M. Atencia and J. Euzenat. 'Knowledge improvement and diversity under interaction-driven adaptation of learned ontologies'. In: AAMAS 2021 - 20th ACM international conference on Autonomous Agents and Multi-Agent Systems. London, United Kingdom, 2021, pp. 242–250. URL: https://hal.archives-ouvertes.fr/hal-03426130.

[3] J. Euzenat. 'Crafting ontology alignments from scratch through agent communication'. In: *PRIMA 2017: Principles and Practice of Multi-Agent Systems*. Ed. by B. An, A. Bazzan, J. Leite, S. Villata and L. van der Torre. Nice, France: Springer Verlag, 2017, pp. 245–262.

[4] 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.

[5] J. Euzenat and P. Shvaiko. *Ontology matching*. en. 2^{nd}. Heidelberg (DE): Springer-Verlag, 2013. 520 pp. URL: http://book.ontologymatching.org.

10.2 Publications of the year

International peer-reviewed conferences

[6] N. Abbas, A. Bazin, J. David and A. Napoli. 'A study of the discovery and redundancy of link keys between two RDF datasets based on partition pattern structures'. In: *Proc. 16th International conference on Concept Lattices and their Applications (CLA)*. CLA 2022 - 16th International Conference on Concept Lattices and Their Applications. Vol. 3308. CEUR Workshop Proceedings Paper 14. Tallinn, Estonia: No commercial editor., 2022, pp. 175–189. URL: https://hal.science/hal-03933868.

[7] Y. Bourahla, M. Atencia and J. Euzenat. 'Knowledge transmission and improvement across generations do not need strong selection'. In: *Proc. 21st ACM international conference on Autonomous Agents and Multi-Agent Systems (AAMAS)*. AAMAS 2022 - 21st ACM international conference on Autonomous Agents and Multi-Agent Systems. online, United States: ACM, 2022, pp. 163–171. URL: https://hal.science/hal-03939919.

[8] Y. Bourahla, J. David, J. Euzenat and M. Naciri. 'Measuring and controlling knowledge diversity'. In: *Proc. 1st JOWO workshop on formal models of knowledge diversity (FMKD)*. FMKD 2022 - 1st JOWO workshop on formal models of knowledge diversity (FMKD). Jönköping, Sweden: No commercial editor., 2022. URL: https://hal.science/hal-03905183.

[9] J. Euzenat. 'Beyond reproduction, experiments want to be understood'. In: *Proceedings 2nd workshop on Scientific knowledge: representation, discovery, and assessment (SciK)*. SciK 2022 - 2nd workshop on Scientific knowledge: representation, discovery, and assessment. Lyon, France, 2022, pp. 774–778. DOI: 10.1145/3487553.3524676. URL: https://hal.science/hal-03905184.

National peer-reviewed Conferences

[10] Y. Bourahla, M. Atencia and J. Euzenat. 'Transmission de connaissances et sélection'. In: *Actes 30e journées francophones sur Systèmes multi-agent (JFSMA)*. JFSMA 2022 - 30e journées francophones sur Systèmes multi-agent. Saint-Étienne, France: Cepadues, 2022, pp. 63–72. URL: https://hal.science/hal-03905182.

[11] Y. Bourahla, M. Atencia and J. Euzenat. 'Transmission de connaissances et sélection'. In: Journées Francophones sur les Système Multi-Agents. Saint-Etienne, France, 27th June 2022. URL: https://hal.science/hal-03808430.

Edition (books, proceedings, special issue of a journal)

[12] *Post-actes de la Conférence Nationale en Intelligence Artificielle (CNIA 2018-2020)* 3 (2022). URL: https://hal.science/hal-03905197.

[13] P. Shvaiko, J. Euzenat, E. Jiménez-Ruiz, O. Hassanzadeh and C. Trojahn, eds. *Ontology Matching 2022 : Proceedings of the 17th International Workshop on Ontology Matching (OM 2022) co-located with the 21th International Semantic Web Conference (ISWC 2022), Hangzhou, China, virtual conference, October 23, 2022*. Vol. 3324. CEUR Workshops Proceedings. CEUR-WS.org, 2022, pp. 1–230. URL: https://hal.science/hal-03939885.

Doctoral dissertations and habilitation theses

[14] K. Jradeh. 'Optimised tableau algorithms for reasoning in the description logic ALC extended with link keys'. Université Grenoble Alpes [2020-....], 12th July 2022. URL: https://theses.hal.science/tel-03885469.

Reports & preprints

[15] N. Abbas, A. Bazin, J. David and A. Napoli. *Discovery of Link Keys in RDF Datasets Based on Pattern Structures*. 31st Jan. 2023. URL: https://hal.science/hal-03964433.

[16] L. van den Berg and J. Euzenat. *The small Class? gamebook*. 2022. URL: https://hal.science/hal-03905186.

Other scientific publications

[17] I. Bloch, J. Euzenat, J. Lang and F. Schwarzentruber. *Introduction*. 2022. DOI: 10.5802/roia.28fr. URL: https://hal.science/hal-03905181.

10.3 Cited publications

[18] M. Anslow and M. Rovatsos. 'Aligning experientially grounded ontologies using language games'. In: *Proc. 4th international workshop on graph structure for knowledge representation, Buenos Aires (AR)*. 2015, pp. 15–31.

[19] M. Atencia and M. Schorlemmer. 'An interaction-based approach to semantic alignment'. In: *Journal of web semantics* 13.1 (2012), pp. 131–147.

[20] R. Axelrod. 'The dissemination of culture: a model with local convergence and global polarization'. In: *Journal of conflict resolution* 41.2 (1997), pp. 203–226.

[21] P. Chocron and M. Schorlemmer. 'Attuning ontology alignments to semantically heterogeneous multi-agent interactions'. In: *Proc. 22nd European conference on artificial intelligence (ECAI), The Hague (NL)*. 2016, pp. 871–879.

[22] P. Chocron and M. Schorlemmer. 'Vocabulary alignment in openly specified interactions'. In: *Journal of artificial intelligence research* 68 (2020), pp. 69–107. DOI: 10.1613/jair.1.11497.

[23] A. Mesoudi, A. Whiten and K. Laland. 'Towards a unified science of cultural evolution'. In: *Behavioral and brain sciences* 29.4 (2006), pp. 329–383.

[24] M. Spranger. *The evolution of grounded spatial language*. Language science press, Berlin (DE), 2016.

[25] L. Steels, ed. *Experiments in cultural language evolution*. John Benjamins, Amsterdam (NL), 2012.