



Christian Alrabbaa, <u>Stefan Borgwardt</u>, Tom Friese, Patrick Koopmann, Julián Méndez, Alexej Popovič Technische Universität Dresden, Center for Perspicuous Computing (CPEC)

Explaining Description Logic Entailments in Practice with **EVEE** and **EVONNE**

3rd Workshop on Explainable Logic-Based Knowledge Representation (XLoKR'22), 31st July, 2022

Description Logics and Ontologies

Description Logics

- Well-established formalism for specifying terminological knowledge in Ontologies
- Applications in biology, medicine, semantic web, and more
 - SNOMED CT: medical, over 300,000 concepts
 - BioPortal: repository of bio-medical ontologies, currently hosting 1,004 ontologies defining 14,685,604 terms
 - MOWLCorp: ontologies obtained by web-crawling, containing 20,996 ontologies



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 - MOWLCorp: ontologies obtained by web-crawling, containing 20,996 ontologies
- With increasing complexity of the ontology, understanding entailments becomes both crucial and difficult
 - Requirement for tools to explain entailments



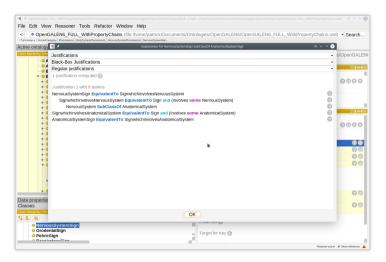
Current Explanation Tool of Choice: Justifications

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	 Target for Key 	



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Current Explanation Tool of Choice: Justifications





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Justifications

Justifications: Minimal subsets entailing given statement

In practice often insufficient:

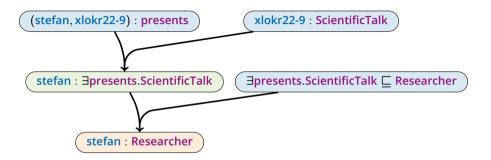
- can be large
- inferences often not obvious

Showing how to obtain the inference would be better

- simple reasoning steps leading to conclusion
- generally known as proof



A Proof





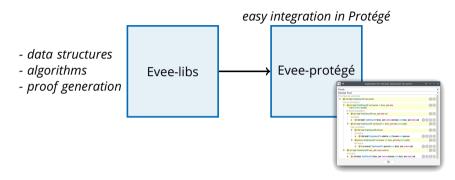
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- data structures

- algorithms
- proof generation

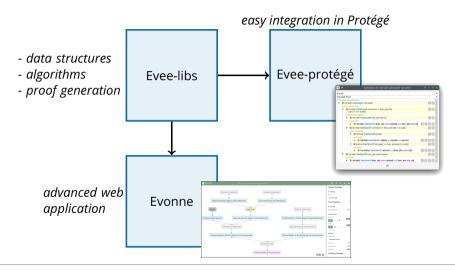
Evee-libs







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Proof Generation in Evee-libs

Three basic methods:

- Proofs based on ELK
- Elimination proofs based on LETHE and FAME
- Detailed proofs based on LETHE

In addition:

- Optimization criteria
 - Proof with lowest (weighted) size or depth
- Hide inferences of known terms



1 Proofs Based on FLK

ELK is the state-of-the-art reasoner for the lightweight logic \mathcal{EL}

- good performance on large-scale ontologies
- reasoning based on inference rules

$\mathcal{E}\mathcal{L}$ inference rules

$$R_{0} \xrightarrow{C \sqsubseteq C} R_{\top} \xrightarrow{R_{\Box}} R_{\Box} \xrightarrow{C \sqsubseteq D} \xrightarrow{D \sqsubseteq E} R_{n,1} \xrightarrow{C \sqsubseteq D \sqcap E} R_{\bot} \xrightarrow{C \sqsubseteq \exists r.D} \xrightarrow{D \sqsubseteq \bot} R_{\bot} \xrightarrow{C \sqsubseteq \exists r.D} \xrightarrow{D \sqsubseteq \bot} R_{\square} \xrightarrow{C \sqsubseteq \exists r.D} \xrightarrow{D \sqsubseteq \bot} R_{\square} \xrightarrow{C \sqsubseteq \exists r.D} \xrightarrow{C \boxtimes a r.D} \xrightarrow{C \boxtimes a$$

- existing library and Protégé plugin (Kazakov, Klinov, Stupnikov 2017)
- we add support for optimized proofs (size, depth)



2. Elimination Proofs

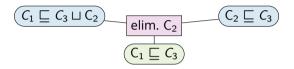
- Support expressive DLs, no need of explicit inference rules
- Based on one type of inference:



- Eliminate symbols one by one, until only the conclusion is left
- Computed using forgetting tools LETHE and FAME

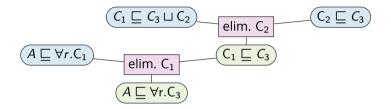


Example of an Elimination Proof



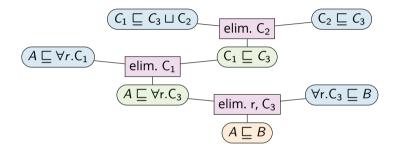


Example of an Elimination Proof





Example of an Elimination Proof





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2. Elimination Proofs

The order in which we eliminate symbols affects the proof size!

How to choose a good order?



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The order in which we eliminate symbols affects the proof size!

How to choose a good order?

We implemented three strategies:

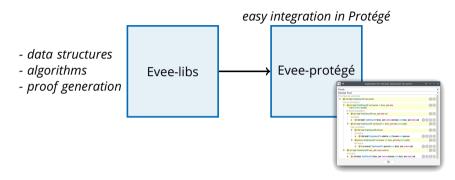
- 1. Use heuristics to pick next symbol (LPAR-20/XLoKR-20)
- 2. Use best-first search together with optimization criterion (IJCAR-22)
 - minimize number of eliminated names
 - optimize for given criterion, e.g. (weighted) tree size



3. Detailed Proofs using LETHE

- Elimination proofs give a high-level perspective on inferences
- Detailed proofs based on LETHE's inference rules
- However, several challenges needed to be solved:
 - LETHE uses a normal form, which we have to denormalize
 - optimizations need to be deactivated
 - some inferences are performed indirectly through the algorithm, which need to be translated to rule inferences







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Evee-protege

- Protégé: standard editor for OWL ontologies
- Easy installation using plugin infrastructure

<u> </u>	Explanation for 'old lady' SubClassOf 'cat owner'	* ~ ^
Proofs		
Detailed Pr	foo	
	r entailment	
두 😑 'old lady' SubClassOf 'cat owner'		?@
	elimination	
	'old lady' SubClassOf 'cat owner' or (has_pet only (cat and (not (cat))))	?@
	perty propagation	
¥.	old lady' SubClassOf has_pet only cat	?@
	normalize bound by the set of	0080
÷.	old lady' SubClassOf 'cat owner' or (has_pet only (not (cat)))	20
	class resolution	
	🐐 😑 'old lady' SubClassOf person	?@
	normalize	0080
	person SubClassOf 'cat owner' or (has_pet only (not (cat)))	20
	normalize	
	🖕 😑 'cat owner' EquivalentTo person and (has_pet some cat)	?@XO
¥. 🔴	'old lady' SubClassOf has_pet some animal	?0
no	malize	
	old lady' SubClassOf (has_pet some animal) and (has_pet only cat)	?@XO
	ОК	



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User Study

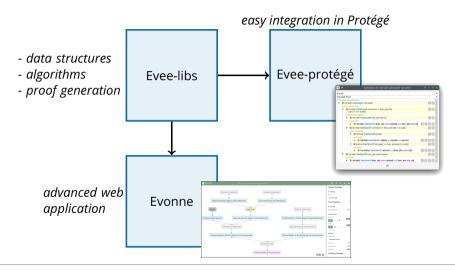
We performed a small user study on Evee -protege

- Participants: 10 DL experts
- 5 Tasks + Questions
- Compare different proof methods

First conclusions:

- Preferred method is subjective
- Proof navigation in Protégé sometimes limited



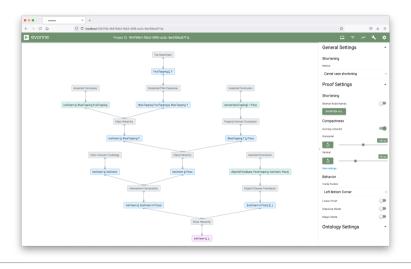




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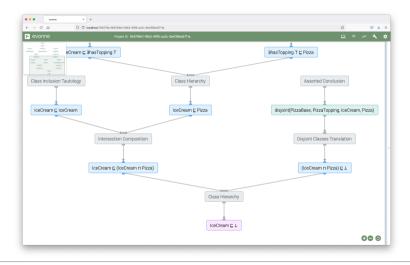
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Advanced Proof Navigation with Evonne

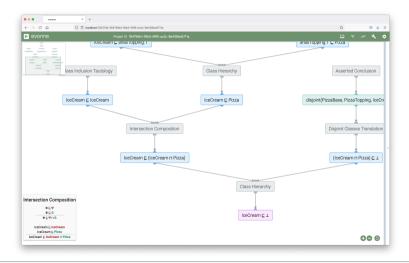




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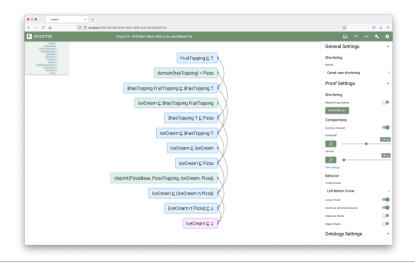




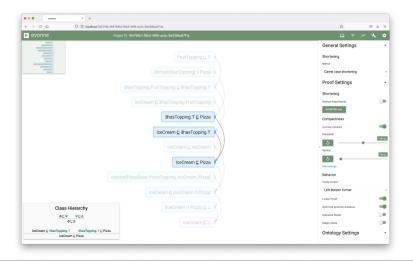




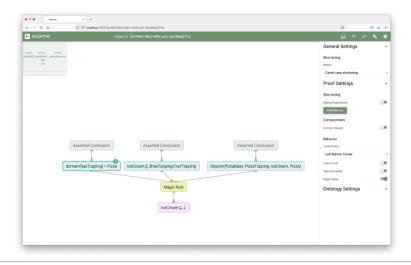
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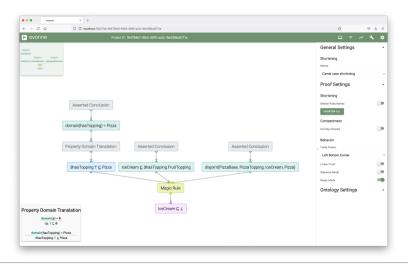




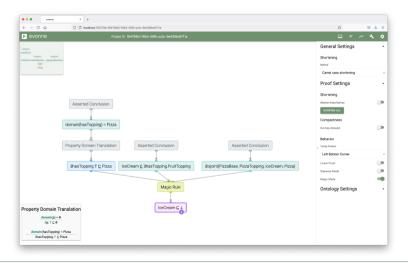








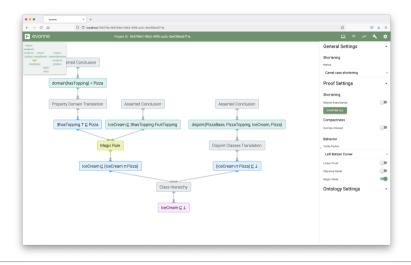






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Advanced Proof Navigation with Evonne





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Proofs to explain DL entailments

- Library Evee-libs used by frontends Evee-protege and Evonne
- ELK proofs, elimination proofs, detailed LETHE proofs
- Optimization w.r.t. various measures



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Future work:

- User study of Evonne
- Explain also non-entailments using interpretations or abduction



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Try it out!

- You can try EVONNE online
- Demo at DL (9.8., 16:00-16:30; 10.8., 10:30-11:00)







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Thank you!





