

A review and comparison of ontology-based approaches to robot autonomy

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Abstract and contribution

Soon robots will need to autonomously execute a large variety of tasks in a large variety of environments. The programming effort can be reduced by developing re-usable knowledge modules. However, this requires at least an agreement on the meaning of the terms. A common approach is to constrain these terms using ontology languages that conceptualize the respective domain.

This work reviews projects that use ontologies to support robot autonomy. It selects projects that fulfill a set of relevant criteria, and compare them relatively to the scope of the used ontology, to the cognitive capabilities these ontologies support, and to the chosen application domain.

The result is a landscape of how ontologies are used to support robot autonomy.

First classification level - Ontological scope

Term	KnowRob 1/2	ROSETTA	ORO	CARESSES	OROSU	PMK
Objects	Yes/Yes	Yes	Yes	No	Yes	Yes
Environment map	Yes/Yes	No	No	No	Yes	Yes
Affordance	No/ Yes	No	Yes	No	Yes	No
Action	Yes/Yes	No	Yes	Yes	Yes	Yes
Task	No/ Yes	Yes	Yes	No	No	Yes
Activity	No/No	No	No	Yes	No	No
Behavior	No/No	No	No	No	No	No
Function	No/No	No	No	No	No	Yes
Plan	No/ Yes	No	Yes	No	No	No
Method	No/ Yes	No	No	No	No	No
Capability	Yes/Yes	Yes	No	No	No	Yes
Skill	No/No	Yes	No	No	No	No
Hardware	Yes/Yes	Yes	Yes	No	Yes	Yes
Software	Yes/Yes	Yes	No	No	Yes	Yes
Interaction	No/No	No	No	No	No	No
Communication	Yes/No	No	No	No	No	No

Largely covered

Poorly covered

Table 1 List of relevant terms for the autonomous robotics domain, and their coverage in the different chosen works. *Yes* and *No* state for when the term is or not covered by the ontology of the specific framework. Note that in the cases when the term is needed and taken from the upper ontology used within the framework, and/or when the knowledge is captured using a similar term, it is considered that the term is covered. If the upper ontology contains the term but it is not used, we consider that the term is not included.

Second classification level - Cognitive scope

Cognitive Capability	KnowRob	ROSETTA ORO	CARESSES OROSU	PMK
Recognition and categorization	Beßler et al. 2019	-	Ros et al. 2010	Menicatti et al. 2017
Decision making and choice	-	-	Bruno et al. 2019	Diab et al. 2017 2019
Perception and situation assessment	Beetz et al. 2015	-	Ros et al. 2010 Sisbot et al. 2011	Diab et al. 2019
Prediction and monitoring	Tenorth et al. 2012	-	-	-
Problem solving and planning	Beßler et al. 2018 Tenorth et al. 2012	-	-	-
Reasoning and belief maintenance	Beßler et al. 2018 Tenorth et al. 2010	-	Warnier et al. 2012	Bruno et al. 2019 Diab et al. 2019
Execution and action	Beetz et al. 2010 Tenorth et al. 2014 2010	Stenmark et al. 2015	-	Sgorbissa et al. 2018 Gonçalves et al. 2015
Interaction and communication	Yazdani et al. 2018	-	Ros et al. 2010 Lemaignan et al. 2011	Bruno et al. 2018 , 2019
Remembering, reflection and learning	Beetz, Beßler, Haidu, et al. 2018 Beetz, Tenorth and Winkler 2015	Stenmark et al. 2018 Topp et al. 2018	-	-

Emergent field

Largely covered

Poorly covered

Table 2 List of cognitive capabilities for the autonomous robotics domain and their coverage in the different chosen frameworks/ontologies. It is possible to find the reference to the articles in which the different reasoning capabilities are addressed using the ontologies.

Third classification level - Application domain scope

Framework	KnowRob	ROSETTA	ORO	CARESSES	OROSU	PMK
Application Domain	Service	Industrial	Service	Service	Service	Service

Poorly covered

Final remarks and conclusion

- Ontologies have **proved** to be **valuable** for the robotics domain in order to support robot **autonomy**;
- the effort should be **continued** and **extended** with new applications;
- it is still pending to **promote** the **reuse** of existing ontologies, which seeks for homogeneity and interchangeability among different frameworks. This will only be possible if researchers:
 - **share** and properly document their contributions; and;
 - can easily **find** work already done in the domain.

We have summarized part of the content of our article on a web page^[1] where users can access the major findings of our work. Our aim is to continuously maintain and improve this page to provide researchers and ontology users easy access to related work. Specifically, the page will allow to search/select by projects and by each of the three scopes proposed along our work.

[1] <https://ease-crc.org/ontology-survey-2019>

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**THANK YOU
FOR YOUR ATTENTION!**