

A Survey about the Usage of Semantic Technologies for the Description of Robotic Components and Capabilities

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Motivation- Assistance of Robotic Solutions Developers



Goal:

Helping robotic developer to build and reconfigure robotic solutions

- Reducing the reconfiguration overhead
- Reducing the requirement of domain knowledge and expertise e.g. in ROS, Hardware components

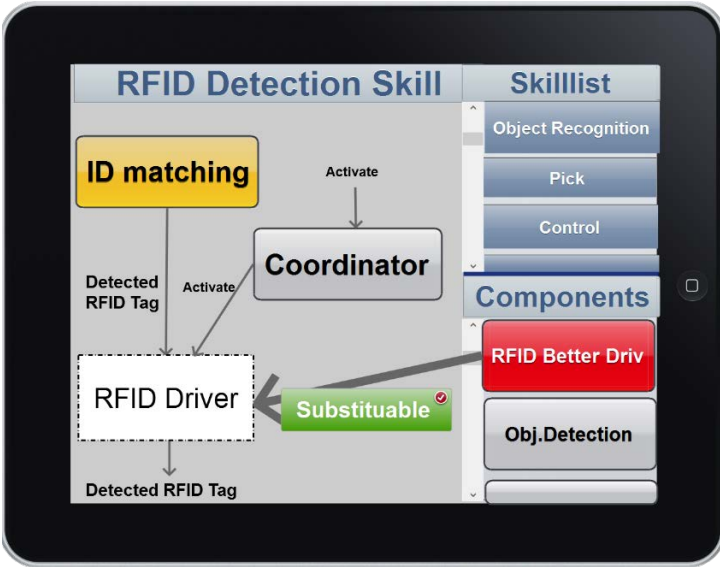


Idea:

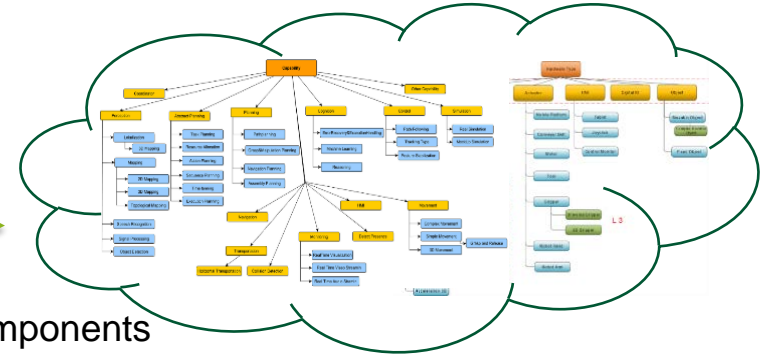
Building application templates in which 3rd party components can be dynamically integrated based on a semantic description of their functionalities



Motivation- Template Based Development of Robot Solutions Using Ontological Semantics

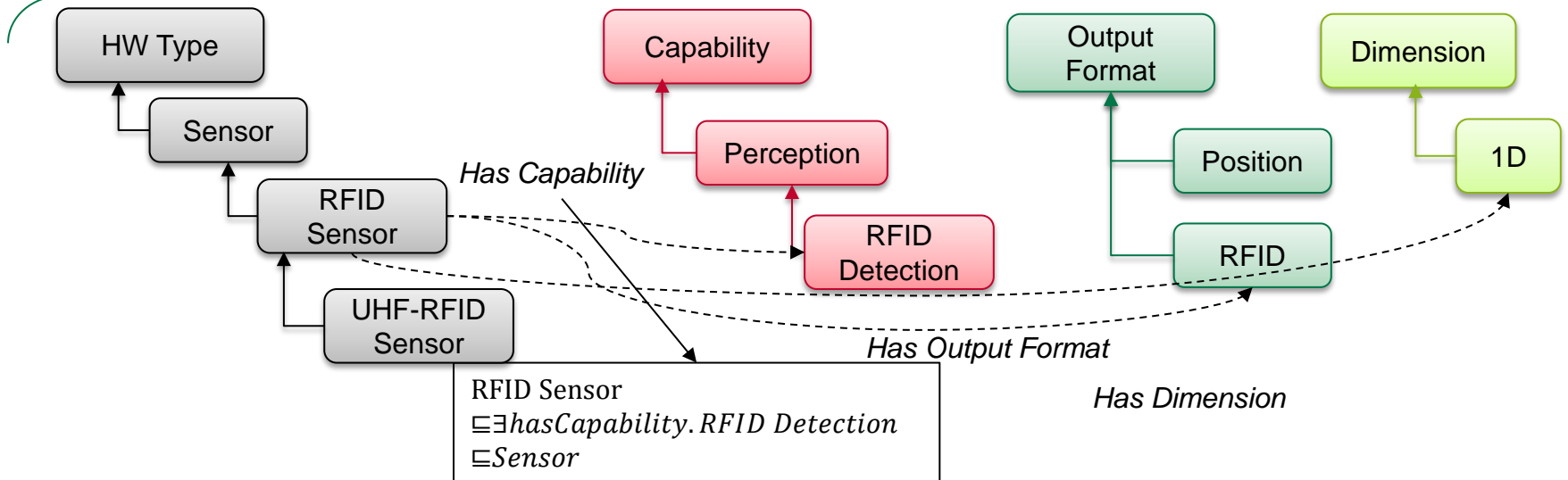


ReApp Ontologies
<http://ipe-id.fzi.de/ontologies/reapp/>



Get suitable Components

based on a multidimensional components classification

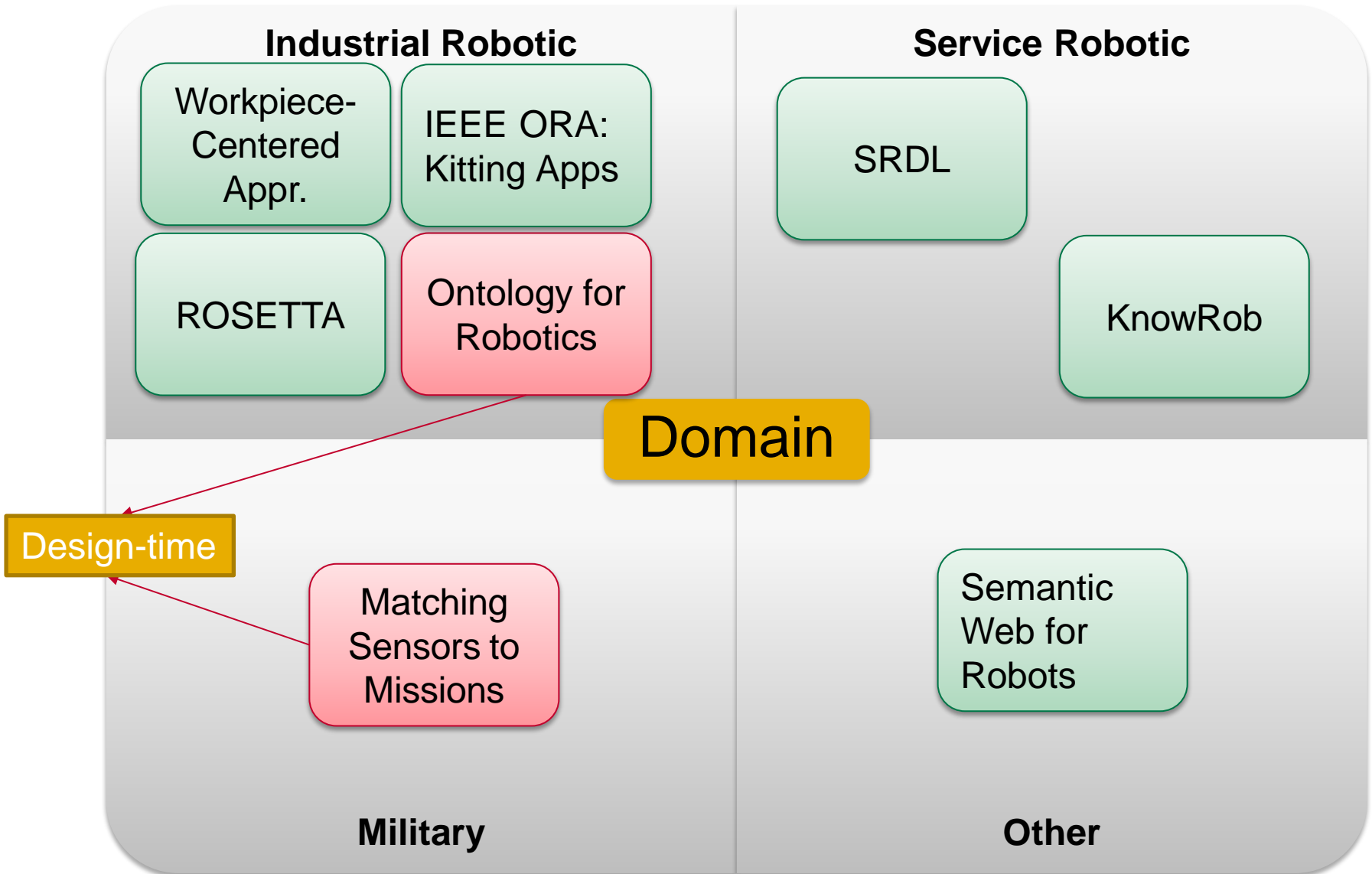


Overview of Analyzed Works



Project Name	Publications	Year
Matching Sensors to Missions	Matching Sensors to Missions Using a Knowledge-Based Approach [23]	2008
Ontology for Robotics: a Roadmap	Ontology for Robotics: a Roadmap [21]	2009
A Workpiece-Centered Approach	Model-Based Configuration – A Workpiece-Centered Approach [5]	2009
KnowRob	KnowRob – Knowledge Processing for Autonomous Personal Robots [25]	2009
	The Semantic Robot Description Language [16]	2011
	Knowledge Processing for Autonomous Robot Control [26]	2012
	KnowRob – A Knowledge Processing Infrastructure for Cognition-enabled Robots [27]	2013
SRDL	The Semantic Robot Description Language [16]	2011
ROSETTA	Automatic Generation of Robot Applications Using a Knowledge Integration Framework [19]	2010
	A Knowledge Integration Framework for Robotics [22]	2010
	Knowledge and Skill Representations for Robotized Production [7]	2011
	Knowledge for Intelligent Industrial Robotics [6]	2012
Semantic Web for Robots	Using semantic technologies to describe robotic embodiments [13]	2011
	Semantic Web for Robots [12]	2012
IEEE ORA WG: Kitting Applications	Knowledge Driven Robotics for Kitting Applications [3]	2013
	Implementation of an Ontology for Industrial Robotics [4]	2014

Categorization after Domain Features



Ontology Scope



	Ontology Scope								
	Sensor	Actuator	Software	Task	Capability	Information Object	Product / Workpiece	Composition	Robot Group
Matching Sensors to Missions	✓	–	–	✓	✓	–	–	✓	✓
Ontology for Robotics: a Roadmap	✓	✓	–	✓	✓	–	–	✓	–
A Workpiece-Centered Approach	✓	✓	(✓)	✓	–	(✓)	✓	✓	✓
KnowRob	✓	✓	✓	✓	✓	✓	–	✓	(✓)
SRDL	✓	✓	✓	✓	✓	✓	–	✓	?
ROSETTA	✓	✓	✓	✓	✓	✓	✓	✓	✓
Semantic Web for Robots	✓	✓	–	(✓)	✓	–	–	✓	?
IEEE ORA WG: Kitting Applic.	?	?	(✓)	✓	(✓)	✓	✓	?	?

Reasoning

	Reasoning: General Features						
	Automated Classification	Multi-dimensional Classification	Capability Aggregation	Robot System Integration	Action Completion	Instruction Completion	Realtime Performance
Matching Sensors to M.	✓	✓	✓	?	–	–	–
Ontology for Robotics	?	–	–	?	–	–	–
Workpiece-Centered	?	?	?	–	✓	–	–
KnowRob	✓	?	✓	–	✓	✓	✓
SRDL	✓	?	✓	–	?	–	✓
ROSETTA	✓	?	✓	–	✓	✓	?
Semantic Web for Robots	✓	✓	✓	–	–	–	?
Kitting Applications	?	?	?	–	✓	?	✓

Reasoning-Matching

	Reasoning: Matching			
	Component-Task Matching	Ranking Matchings	Filter-Based Matching (Resource Allocation)	Filter by Run-Time Component Status
Matching Sensors to Missions	✓	–	(✓)	–
Ontology for Robotics: a Roadmap	✓	–	✓	–
A Workpiece-Centered Approach	✓	✓	✓	–
KnowRob	✓	?	✓	?
SRDL	✓	?	✓	–
ROSETTA	✓	?	?	–
Semantic Web for Robots	✓	–	✓	?
IEEE ORA WG: Kitting Applic.	?	?	?	?

Technological Foundation

	Technological Foundation		
	Ontology	Reasoning	Other
Matching Sensors to Missions	OWL DL	Pellet	Set-Covering Algorithm
Ontology for Robotics: a Roadmap	OWL-S	JastAdd	
A Workpiece-Centered Approach	OWL	?	CAD Application
KnowRob	OWL	SWI Prolog	YARP, RoLL URDF, ROS
SRDL	OWL	SWI Prolog	URDF
ROSETTA	OWL/RDF	Jena2/RIF	SPARQL, Collada, ABB RobotStudio
Semantic Web for Robots	OWL(-S)	SWRL/Jena	TDB, Joseki
IEEE ORA WG: Kitting Applic.	OWL,XML	?	PDDL, ROS, CRCL

Additional Features

	Additional Features				
	Grounding Problem	Managing Uncertainty	Natural Language Processing	Failure Handling / Recovery	Injury Risk Management
Matching Sensors to Missions	(✓)	-	-	-	-
Ontology for Robotics	-	-	-	-	-
A Workpiece-Centered Approach	?	?	-	?	-
KnowRob	✓	✓	✓	?	-
SRDL	-	-	-	-	-
ROSETTA	?	✓	✓	✓	✓
Semantic Web for Robots	-	-	-	-	-
IEEE ORA WG	✓	✓	-	✓	?

Summary



- Ontologies are a well-suited and promising technique in the Field of robotics.
- There is not one formal, explicit specification of a shared conceptualization of robot components, their capabilities and tasks
- Our Contribution is a survey about recent approaches from the domains of robotics specially that uses semantic Web technologies and ontology-based knowledge representation frameworks for the description of hardware and software components together with their capabilities.
- We created a classification framework that analyzes domain and purpose of each approach, the ontology features and ontology language used together with the aspects scope and extensibility.
- We analyzed also the reasoning problems

Questions?