Overview of IEEE Robotics Standards

Presentation to the C2SIM AXS Group

Elizabeth Hosang, July 2024

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Acronyms

- AuR – Autonomous Robots

- ALFUS – Autonomy Levels for Unmanned Systems

- CORA – Core Ontology for Robotics and Automation

- CORAX – CORA Extension. Aspects of reality necessary for modelling, but not explicitly covered by SUMO.

- DOLCE – Descriptive Ontology for Linguistic and Cognitive Engineering

- DUL – DOLCE ultra-light.

- ORA – Ontology for Robotics and Automation

- POS – Position and Orientation ontology

- R&A – Robotics and Automation

- SUMO – Suggested Upper Merged Ontology

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Presentation Overview

- The purpose of this presentation is to evaluate 1872.2-2021 IEEE Autonomous Robotics (AuR) Ontology to see if it defines concepts that could be used in defining the C2SIM extension for Autonomous Vehicles.

- AuR is an extension to 1872-15 IEEE Standard for Ontologies for Robotics and Automation, which defines the Core Ontology for Robotics and Automation (CORA).

- CORA uses concepts defined in the Suggested Upper Merged Ontology (SUMO) (The Suggested Upper Merged Ontology (SUMO) – Ontology Portal).

- AuR also uses SUMO, but it is not tied to an upper-level ontology. It also uses the Descriptive Ontology for Linguistic and Cognitive Engineering (DOLCE) ultra-lite (DUL). [2308.01597] DOLCE: A Descriptive Ontology for Linguistic and Cognitive Engineering (arxiv.org)

- Therefore, to understand the concepts in AuR, we need to touch on the other standards.

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Standard Overview: Suggested Upper Merged Ontology (SUMO)

- "Largest formal public ontology in existence today" (according to the website)

- Contains concepts across multiple domains: Communications, Countries and regions, Distributed computing, User Interfaces, etc.

- Useful concepts from SUMO, as identified in AuR:

  - Attribute – Qualities that cannot be or are chosen not to define as subclasses.

  - Case Role – Class of predicates relating the spatially distinguished parts of a process.

  - Corpuscular Object – A self-connected object whose parts have properties that are not shared by the whole.

  - Process – The class of things that happen and have temporal parts or stages.

  - Proposition – Abstract entity that expresses a complete thought or set of thoughts.

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SUMO Key Concepts for CORA

- Agent

- Artifact

- Measure

- Object

- Electric Device

- Computer Process

- Device

- Group

- Measuring Device

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Standard Overview: Descriptive Ontology for Linguistic and Cognitive Engineering (DOLCE)

- "First top-level (foundational) ontology to be axiomatized"
- Provides general categories and relations.
  - Event – any physical, social, or mental process, event or state.
  - Goal – Description of situation desired by an agent, usually associated to a plan that describes how to achieve it.
  - Information Object – Any piece of information: musical composition, text, word, etc. independent from how it is concretely realized.
  - Physical Object – Any object that has a proper space region.
  - Quality – Any aspect of an entity that cannot exist without the entity, e.g. specific light of a place at a certain time.
  - Role – Concept that classifies an object.

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Standard Overview: IEEE 1872-2015 CORA

- IEEE 1872-2015 Standard Ontologies for Robotics and Automation (CORA)

- Covers basic concepts to describe robotics: parts, processing, environment, behavior, etc.

- Uses concepts from SUMO: Object, Artifact, Agent, Group, Process, etc.

- Defines CORAX: ontology defining aspects of reality that are necessary for modelling, but too general for SUMO or CORA.

  - Examples: PhysicalEnvironment, Interaction (type of Process (SUMO), ProcessingDevice, etc.

- Defines POS: Position and Orientation.

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Key Concepts from CORA (1/2)

- Robot – Agent Device purposed to act in the physical world in order to accomplish one or more tasks.

- Robot Part – Any device attached to a robot that serves in its functioning, e.g. Sensing, Communicating, Actuating, Processing

- CollectiveRoboticSystem – Two or more robots that are assumed to collaborate in some way to achieve a common goal.

  - Each may have its own goal that is a subgoal of the larger one.

  - The robots may not communicate with each other directly, e.g. assembly line.

- RobotGroup

- RoboticSystem

- RoboticEnvironment

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Key Concepts from CORA (2/2)

- Roles:

  - Fully Autonomous

  - Remote Controlled

  - Automated – not adaptive,

  - Teleoperated – human operator either directly controls or assigns incremental goals based on a continuous basis.

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Key Concepts from CORAX

- Physical Environment

- Interaction – not defined in SUMO

- Artificial System

- Robot Motion – any process where a robot moves one of its parts

- HumanRobotCommunication

- RobotRobotCommunication

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Key Concepts in POS

- PositionCoordinateSystem

- PositionMeasure

- PositionPoint

- PositionTransformation – between two coordinate systems.

- PositionRegion

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Key Concepts in AuR – Behavior Subtypes

- Architectural behavior – Internal organization of the flow of information that determines the object's behavior. Subtypes:

  - Reactive

  - Deliberative

  - Cognitive

- Emergent behavior – Set of relationships chosen to describe the object relevant interactions. Is an Information Object (DUL) / Proposition (SUMO)

- Engineering behavior – Manifested behavior given by a set of state variables.

- Manifested behavior – Evolution of the object's qualities and the relationships holding among that object and any other objects participating in the event.

- Rule behavior – Set of rules and decision methods that an agent has and can use to decide its actions.

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Key Concepts in AuR – Other

- Function – Role that the manifested behavior of the object plays in an event.

- Interaction
  - Information Interaction
  - Physical Interaction
  - Manifested behavior

- Object-centered environment

  - Examples: environment of an industrial robotic arm is the location / spatial area that the robot can potentially reach during the time of an event.

- Object-centered environment description

- Physical Interaction

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Summary and Next Steps

- Some of the concepts in the three referenced standards (SUMO, DUL and CORA) can be mapped to concepts in the C2SIM core models, e.g. Agent, Event, Physical Environment.

- Concepts from AuR such as Behavior and Interactions also overlap with key C2SIM concepts.

- Possible next steps:

  - Identify concepts from these standards that may be relevant to Autonomous system use cases, e.g. communication between entities.

  - Map these concepts against the C2SIM core model to identify concepts that lack corresponding entities in C2SIM.

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Thank you!

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