OPC UA NodeSet Ontologies as a Pillar of Representing Semantic Digital Twins of Manufacturing Resources

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Dokumenttyp: Konferenzbeitrag

Titel des Beitrags: OPC UA NodeSet Ontologies as a Pillar of Representing Semantic Digital Twins of Manufacturing Resources

Abstract: The effectiveness of cognitive manufacturing systems in agile production environments heavily depends on the automatic assessment of various levels of interoperability between manufacturing resources. For taking informed decisions, a semantically rich representation of all resources in a workcell or production line is required. OPC UA provides means for communication and information exchange in such distributed settings. This paper proposes a semantic representation of a resource's properties, in which we use OWL ontologies to encode the information models that can be found in OPC UA NodeSet specifications. We further combine these models with an OWL-based description of the resource's geometry and -- if applicable -- its kinematic model. This leads to a comprehensive semantic representation of hardware and software features of a manufacturing resource, which we call semantic digital twin. Among other things, it reduces costs through virtual prototyping and enables the automatic deployment of manufacturing tasks in production lines. As a result, small-batch assemblies become financially viable. In order to minimize the effort of creating OWL-based UA NodeSet descriptions, we provide a software tool for the automatic transformation of XML-based NodeSet specifications that adhere to the OPC Foundation's NodeSet2 XML schema.

Kongress-/Buchtitel: Proceedings of the IEEE International Conference on Emerging Technologies
And Factory Automation (ETFA)

Jahr: 2019

Monat: Sep

Volltext / DOI: doi:10.1109/ETFA.2019.8868954

Occurences:
- Einrichtungen > Fakultäten > Fakultät für Informatik > Lehrstühle der Informatik > Informatik 6 - Lehrstuhl für Echtzeitsysteme und Robotik (Prof. Knoll) > 2019

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