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Information schema constructs for instantiation and composition of system manifestation features

Key words: System manifestation features; Information schema constructs; Database schemata; SMF genotypes; SMF phenotypes; SMF instances; Software tool box; System-level design; Cyber-physical systems

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Motivation

This research is performed to contribute to system-level modeling of complex and heterogeneous systems, such as cyber-physical systems (CPSs). The objective is to develop a software toolbox for pre-embodiment design of CPSs.

The novelty of this toolbox is that it uses system manifestation features (SMFs) for transdisciplinary modeling of CPSs.

To create models of CPSs, SMFs should be firstly created, and then instantiated and composed together. The creation of SMFs is reported in the previous paper, and instantiation of SMFs and composition of models are discussed in the current paper.

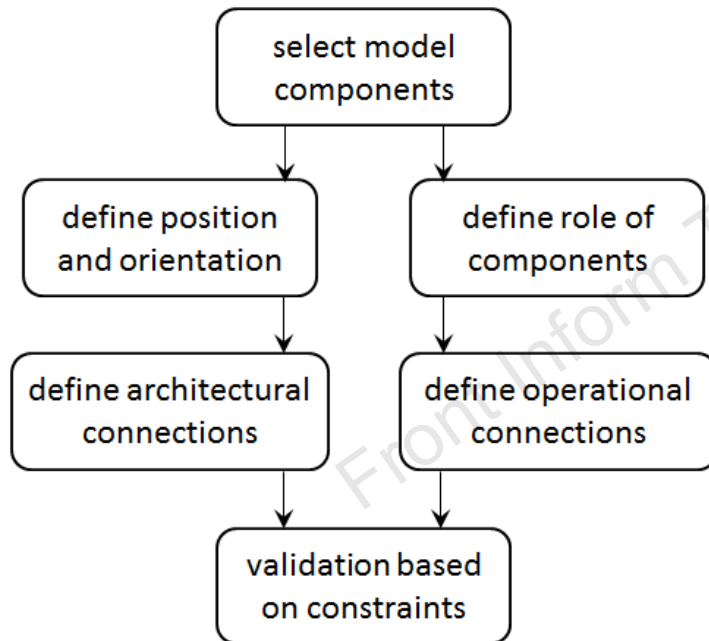
Main idea

The central concept of SMFs is that they are very high-level, transdisciplinary, adaptive, and smart modeling entities that capture architectural and operational semantics.

Information schema construct (ISC) supports the logical arrangement of the data contents of SMF implements in a set of relational tables of varying semantics. An ISC-based approach is proposed to create the associated warehouse databases of SMFs.

To capture the procedure of model composition and instantiation, the concept of procedural computational schema (PCS) has been created, which represents algorithmic activity flows that could be implemented through programming languages.

Generic workflow of pre-embodiment design



SMF-based modeling is a computational implementation of the pre-embodiment design methodology. It includes six major activities of model composition.

This seems to be a sequential workflow, but as shown in the left figure, some activities are done concurrently and in an interrelated manner.

Reported results

The paper reports three inter-related pieces of research to support the mentioned workflow of pre-embodiment design:

- It demonstrate the computational procedures that are in harmony with the designerly way of system composition.
- It focuses on the model database that captures all pieces of information of SMFs in relational tables.
- It demonstrate the meta-level knowledge-base that captures the whole modifications applied in the process of model composition.

Discussion

The information schema constructs together with the proposed entry forms and procedural computational schemata support and confirm feasibility, usability, and utility of SMFs-based modeling of CPSs. From the feasibility perspective, they provide a solid and at the same time flexible basis for programming and implementation of the software toolbox. As logical units, they support implementation as follows:

- The introduced ISCs formalize and regulate large and heterogeneous chunks of SMFs-related information as well as the relations between them.
- The entry forms formalize the process of inputting information. Programming of the user interface is viable based on the introduced entry forms.
- The PCSs determine the information processing and reasoning needed for refining chunks of information, creating connections among them, and modifying the stored information. They can be used as bases for generating procedural codes of SMF-TB.

Discussion

- From the perspective of usability, the proposed constructs and computation enablers operationalize the theoretical specifications that are inevitable for a system-level configuration and conceptualization of CPSs. Usability should be judged by the eyes of CPS designers and having their requirements in mind, since they are the decisive stakeholders.
- From the perspective of utility, the whole methodology and proposed constructs support CPS designers to tackle system composability challenges.

Conclusions

- Using information schema constructs for database development and management for instantiation and composition of system manifestation features is a novel and affordance-rich approach. ISCs help tackle the heterogeneity problem and support multi-granularity.
- The testbed implementation provided some initial insight to the above mentioned three aspects, but it cannot replace long-term testing in benchmark applications. This remains for our future work.
- Our reported work concentrated on the methodology of computation, rather than on the methodology of using the proposed system manifestation features based modeling in various application contexts.