CIAS-DM: A Model-Based, Human-Centered Architectural Modeling Method + Tool

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Design Challenge
A recent trend in architecture is for the built environment to proactively contribute to enhancing human health, well-being, performance, and social interactions in measurable, predictable, and adaptable ways. Buildings are becoming interfaces and digital machines and their roles and capabilities are expanding. Accommodating this trend will require architectural design methods and tools to evolve. Sensing, monitoring, actuation, intelligence, and communication subsystems are now integral components of environmental designers’ vocabularies and considerations when designing space and form. At present, the theories, methods, and tools for representing and incorporating these elements during design do not exist. Developing these artifacts is an active area of research.

This dissertation focuses on representing the affordances of complex, interactive, architectural systems (CIAS) and proposes, evaluates, and refines the Complex Interactive Architectural System Design Methodology (CIAS-DM). The purpose of CIAS-DM is to aid designers in making sure they understand the design challenge well at the start of the project. The Validation Square Research Design is used to evaluate CIAS-DM.

Results are preliminary, but indicate that using a methodology similar to CIAS-DM may be useful for helping designers manage the scope of complex, interactive design challenges.

CIAS: An Example

CIAS Design Challenges:
1. CIAS exist at multiple scales of granularity simultaneously.
2. There are very large degrees of freedom in the system.
3. Real-time interactivity between users, physical & virtual environments, different sub-systems, some of which cannot be modularized.
4. The system’s openness to unknown and unknowable systems external to itself.
5. Extensive collaboration required to design CIAS.
6. Imperfect understanding of goals, use cases, constraints, and/or sensing requirements.
7. Redundancy, scalability, adaptability, safety, and reliability.
8. Lack of adequate design and analysis artifacts.
10. Ability to optimize across all systems simultaneously.
11. Credibility of claims.
12. Lack of adequate design and analysis artifacts.
14. Inability to optimize across all systems simultaneously.
15. The extensive collaboration required to design CIAS.
16. Imperfect understanding of goals, use cases, constraints, and/or sensing requirements.
17. Redundancy, scalability, adaptability, safety, and reliability.
18. Lack of adequate design and analysis artifacts.
20. Ability to optimize across all systems simultaneously.

Mapping the Design Domain

Structure of the Research:
The research did not begin with a theory but with an expansive review of literature and something like a ground-up approach to theory development. Based on the developed theory (classifying complex, interactive architecture as a subclass of cyber-physical systems and socio-technical systems) a developed a method and tool for improving the design of CIAS.

Lessons from the Literature:
How to design these types of projects remains an open question. However, approaches are starting to take shape. All involve a mix of analytical and creative techniques. The analytical techniques ensure that clear, simple, logical aspects of the design challenges are understood and addressed. The creative techniques help uncover the aspects of the challenge that are not immediately obvious based upon a purely logical approach. CIAS-DM also addresses both aspects of the design challenge.

Research Design

Case Study / Qualitative Evaluation

Case Study / Qualitative Evaluation - Rehabilitation Patient Room: Environment of Intelligent/Responsive/Interactive Systems: CIAS-DM is evaluated based upon a series of design challenge scoping exercises for an assistive patient room. Evaluation of the CIAS-DM is qualitative and uses the Validation Square Research Design Methodology [2] with influences from Design Science Research [8, 9]. Data collection is now wrapping up. Preliminary indications are that designers more quickly develop a much clearer understanding of the project scope, the likely interfaces between people and the systems, and are able to hone in more quickly on a focus for the project.

CIAS-DM Method Summary

Method + Tool: CWA Mapped Into SysML

But CIAS-DM extends the SysML profile within MagicDraw. It incorporates dynamic systems diagrams and unties elements from human factors. Specifically, it integrates the first three diagrams of Vicente’s Cognitive Work Analysis (CWA) [14, 15]. In particular, CWA begins to represent the systems that extend the work in the system and the roles they play in extending this work. This is a revolutionary change to how designers represent and communicate about the systems of interest, the problem and proposed solutions.

To these analytic, methodological, and design tools, CIAS-DM adds a method intended to encourage cooperation and discovery at the beginning of the design challenge. It uses iterative prototyping and brainstorming activities to identify design problem spaces and limit the degrees of freedom.