Abstract
Gathering and analyzing Cyber-Physical System requirements pose unique challenges to the requirements engineering community - a perspective that is sensitive to the scoping and interplay between the cyber, physical and behavioral aspects of the system. A model driven requirements analysis approach using various categories of models served as a useful aid in discovering, understanding, and analyzing certain classes of requirements about crucial aspects of the cyber-physical systems which were otherwise latent.

Background
- Cyber-physical systems (CPS) – networked software based systems that extensively interact with the physical world. Eg: Aircraft control devices
- FDA’s initiative explores various methods to improve the safety of medical CPS systems such as infusion pumps.
- Complete and consistent requirements are central to analysis, verification, and assurance for safety.
- Collecting a good set of requirements is not a straightforward task.
- A generic patient controlled analgesia (GPCA) infusion pump system was used as a case example to provide an archetype of system development artifacts that demonstrates safety.

Research Challenges
- Requirements to address the complexity in the continuous domain.
- Requirements categories related to continual behavior of the system
- Precise scoping of the system.
- Understanding requirements and system decomposition.
- Understanding modes and features interactions
- Analyzing system behavior during mode transitions.
- Modeling for change/expansion/contraction.

Requirements Analyses and Modeling Techniques

Control System Modeling
- Evaluate various control strategies
- Explore system responses in its intended environment.
- Identified categories of requirements:
  - Accuracy
  - Rise / Drop Time
  - Rate of Change
  - Overshoot (Max deviation)
  - Settling Time
  - Cumulative Error

Architectural Modeling
- Examine different architectures.
- Visualize hierarchical system decomposition
- Precisely fixed system boundary to express requirements.

Stateflow Modeling
- Complement requirements to understand the dynamic behavior of complex systems.
- Analyze mode-logic requirements and behavior.
- Identified mode-logic modeling patterns that are flexible for changes.
  - Sequential vs Parallel structure of mode logic
  - Complex feature behaviors

Next Steps
- Create assurance cases and perform reasoning to demonstrate GPCA safety
- Create a catalog of requirements patterns to capture system dynamics in the physical domain. (Control System Modeling)
- Develop guidelines for scoping a system and flow-down of requirements to decomposed system components. (Architectural Modeling)
- Build a catalog of solutions for various behavioral modeling problems and build a repertoire of modeling patterns. (Stateflow Modeling)
- Develop a standard set of reference artifacts for demonstrating the safety of CPS systems.

Publications