

Model-based Human Interaction Design

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This paper targets developers of the human interaction of complex, utility-critical systems. The systems of interest are usability-critical systems, including safety-critical systems, productivity-critical systems, home and personal devices, as well as marketing and sales websites.

A primary hurdle to maximizing the system utility is the difficulties that the operators experience when the system is in exceptional situations. The reason for this is that regular training targets normal conditions. During normal operation, the operators encounter exceptional situations only occasionally, which is not sufficient for effective learning. Whenever they encounter an exceptional situation, they waste too much time trying to find their way around it. For example, informal studies on the productivity in text editing indicate that about half of the time is wasted in recovery from errors.

Utility-critical systems should incorporate means, including sensors and data analytics, for informing the operators and the developers about the time they could save. The infrastructure for model-based human interaction may include special means intended to save the time wasted in handling exceptional situations.

Many developers are not aware of the risks of operating in exceptional situations. Therefore, they do not gain the education and resources required to mitigate these risks. Model-based design enables seamless adaptation to design changes. Rule-based models enforce mitigating the risk of operational complexity.

It might be too expensive to develop models dedicated to a particular system. Fortunately, in a prior study on system resilience, we have defined several patterns of handling exceptions. The conclusion is that we can formulate a universal hyper-model, consisting of layers of generic mini-models (GMM), in terms of operational rules. A universal hyper-model proposed here consists of seven layers, such that each layer consists of several GMMs:

- Structural layer: recursive definition, in terms of users, operators, and subsystem
- Risk layer: ways in which the operation might fail
- Functional layer: features of the user interface (UI) required to accomplishing an operator's task
- Static layer: representation of the operational situations
- Dynamic layer: representation of the operational activities
- Behavioral layer: representation of the responses to events
- Resilience layer: representation of safety backups

Each of the GMMs depends on GMMs from the previous layer. For each of the GMMs, we describe the main entities, with a focus on the operational rules. The design focus is on the static layer, which defines and classifies the exceptional situations. A key concept is of scenarios, which enable reducing the complexity of situational transitions by information hiding. Scenario design should enable direct mapping from intentions to actions.

Activities involved in utility-oriented design include:

- Evaluating the benefits and costs of the model
- The infrastructure required for applying the model
- Customizing the model for a particular project
- Applying simulation in the transition to a prototype and/or a digital twin
- The activities in a development cycle
- Setting criteria for design completion
- Designing for testability of rare events, and
- Adjusting the custom parameters by safety and usability needs.