A Cognitive Approach to Designing Human Error Tolerant Interfaces

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Human errors are inevitable, but some are more inevitable than others. Human error has been blamed for countless catastrophes (cf. Casey, 1993; Perrow, 1984), yet errors are often merely symptoms of much larger underlying design problems. Designing for human error is a major challenge for developers of safety-critical and mission-critical systems. Human error is of particular concern for banking, commerce, medicine, military and other systems where tasks are performed with high frequency, or where the consequences of mistakes are grave or costly. Most approaches to error-tolerant design use either general design guidelines or treat humans as just another error-prone system component. To make errors a little less inevitable, we must take a comprehensive, psychologically-based approach to human-error tolerant design.

The goals of this tutorial are to provide researchers with a better understanding of the underlying causes of human error and present practical techniques for applying psychology to human-error tolerant designs. This tutorial approaches error tolerant design from a cognitive perspective, focusing on practical techniques for improving your system's ability to deal with inherent human limitations. Participants will learn the basics of human error, how to classify error types, a framework for error tolerant design, how to deal with multiple aspects of error in design, and how to form a multilayered defense against error.

Understanding Human Error

Reason (1990) defines and discusses many aspects of human error and its psychological underpinnings. Although there are many questions remaining about the attentional mechanisms used by Reason to explain error occurrence, his work provides a starting point from which to study human error and error tolerant design. Reason's human error taxonomy is framed around Rasmussen's Skills-Rules-Knowledge (SRK) framework (1979). In addition to specific error types within each of the SRK levels, Reason also identifies two general forms of error, "similarity matching" and "frequency gambling", that pervade each of the levels. This leads to general rules for erroneous memory retrieval, such as, "If the correct item is not retrieved, then the most similar, frequently accessed item will be retrieved." Additional insight can be gleaned by mapping Reason's taxonomy unto a standard human information processing architecture, such as ACT-R, EPIC or Soar.

Understanding and categorizing human error can be done at many levels, depending on the focus of the study. Reason (1990) also describes different levels for classifying error instances as one of behavioral (observable actions, such as omitting a procedural step), contextual (within the context of the task, such as "failed to press the button"), or conceptual (relating to internal mechanisms, such as "failed to perceive warning label").

Designing Error-Tolerant Systems

Many error-tolerant design efforts rely on general design guidelines (e.g. Smith and Mosier, 1986). However these guidelines are often not used or misapplied because they are sometimes overly general or atheoretical in nature. Mayhew (1992), provides a more theoretical mapping of guidelines into motor, cognitive, and perceptual areas, but has no framework to comprehensively address human error.

An effective error-tolerant design must address multiple aspects of human error to build a comprehensive, multi-layered defense. These aspects include error prevention, reduction, detection, identification, and correction, resumption of normal activities, and failure mitigation. In this tutorial we will describe a framework for mapping between error taxonomies, cognitive architectures and design guidelines, and present a task-analytic technique for applying the framework in a practical way.

Understanding the psychological factors that affect these areas is essential for good design. Likewise, understanding practical implications of applied psychology may lead to further theoretical advances in the field.

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