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Analysis of Communication Breakdowns for eHealth Systems Design

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Introduction

Safety-critical fields such as Air Traffic Control address safety during the design stage by applying task-modeling techniques, and human error prediction of knowledge-based, skill-based and rule-based mistakes and lapses [3]. However, the cooperative nature of the activity is not the primary focus in these approaches. Rather, it is the behavioral or cognitive errors that occur.

Medical services are cooperative activities that involve a number of participants (e.g. physician, nurse, technologist, pharmacist, etc.) who work towards a common goal of providing healthcare. Clinical activity is not only a highly cooperative process, but also safety-critical, collaborative, distributed over time and space, and characterized by high complexity and coordination demands. Communication enables the cooperation, collaboration, and coordination processes [1], and eHealth technology mediates these processes. What, then, are the implications of a communication breakdown?

Technology represents the backbone of the healthcare process. However, it is medical professionals who assume responsibility for the failures of technology [2]. The discussion of human factors in medicine centers on accreditation, licensure, a posteriori analysis of accidents, and decision-making. We propose an adverse-event minded design method for eHealth applications that considers the error-prone nature of the distributed computer-supported medical work process. We model potential breakdowns, afforded by the medium, the task, and the workflow. Our method can account for potential failures and suggest design and workflow solutions to prevent accidents, a priori.

Methods

Medical activity is built on the premises of cooperation, coordination and collaboration. These, in turn, are a function of the success of communication among actors. We propose to expand the focus of design methodology for eHealth systems to consider the processes of joint activity by exploring potential communication breakdowns – interaction fragments between people and/or systems that generate unintended deviations from the activity's trajectory towards a goal. We identify five levels of potential communication failures that produce adverse outcomes in eHealth applications: medium/technology, semantic, coordination, cooperation, and collaboration. The set of interaction configuration scenarios for such failures is: person-to-person, person-to-system-to-person (system-as-mediator), person-to-system, and system-to-system. Our design approach consists of the following steps:

1. Construction of a task model for each participant, a system-side interaction model, and a cooperative activity model (which combines all the other models)
 2. Human error analysis
 3. Identification of potential communication breakdown hotspots
- breakdowns at five levels of analysis: medium/technology, semantic, coordination, cooperation, and collaboration

- the influence of temporal relations
 - the influence of the interaction and space configuration scenario
4. Mapping of predicted failure to anticipated adverse outcomes
 5. Design and/or workflow solutions; suggest redundancy where needed in order to make the process robust and fault tolerant

The method emphasizes the importance of considering the limitations of the intended communication modality (voice, digital, analog, face-to-face, synchronous, etc.) as preconditions to communication failure. Further, an eHealth system is seen as a communication contributor, similar to human participants in the joint activity (no intelligence is attributed to the system though).

Results and Discussion

We applied our method to a typical telemetry monitoring activity scenario, and our breakdowns analyses predicted a great number of potential adverse events. For example, in the abbreviated task model shown in Figure 1, we predict a communication failure between the telemetry monitoring system used to send a page to the physician and the hospital paging system. The associated adverse outcome could be that the physician receives a delayed page. The delay time could, in the worst case, result in a life-threatening or fatal outcome for a patient in serious condition. One proposed solution to this potential risky situation is the utilization of a backup/redundant communication channel between the nurse and the physician.

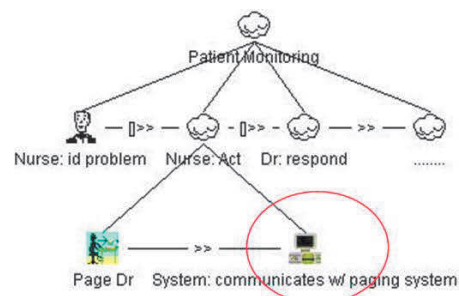


Figure 1: Patient Monitoring task model (abbreviated)

Following our analyses, we looked at the adverse events associated with an existing telemetry patient monitoring system made by a major manufacturer and currently used in a number of hospitals in North America. Over the last thirty months, 19 out of 21 reports about this system submitted to the U.S. Food and Drug Administration MAUDE database are associated with communication breakdowns in one of the levels we propose; 89% of the breakdowns resulted in a life-threatening situation or death. Over half of these failures were predicted by our method.

We argue that the current state of medical processes is impossible without the technology that enables the majority of domain communication and coordination. Thus, technology is a vital participant in joint activity. Anticipating failure in communication patterns – among humans and systems – can lead to design solutions, which prevent fatalities. The goal is to make eHealth applications safer, starting at the design stage.

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