User Interface Design for Dependable Systems in Industrial Automation

46th IFIP WG 10.4 Meeting

Carsten Wittenberg
SIEMENS AG – Corporate Technology
D - 81730 Munich/Germany
Tel.: +49 89 636 57470
Fax: +49 89 636 49428
E-Mail: carsten.wittenberg@siemens.com

dependability.org
Content

- SIEMENS Corporate Technology – User Interface Design
- Introduction & History of UI in Industrial Automation
- The Human Operator
  - Human Information Processing, Mental Models, etc.
- Usability & User-centered Design
  - From use context to evaluated systems
- User Interface Examples
  - Engineering portal
  - Supervisory Control
  - Mobile Devices for Service and Maintenance
SIEMENS
Corporate Technology
User Interface Design
Users „experience“ a product above all through its user interface. Optimized user interaction plays an important role in the competitive markets.
CT IC 7 – User Interface Design Process

Requirements Analysis
- User Profiles & Needs
- Workflows & Use Context
- UI-Trends in the Market
- Ideas for UI Solutions

Design & Specification
- Information & Functional Architectures
- UI Concepts and Solutions: Interaction & Visual Design
- Specifications & Styleguides

Usability Evaluation
- Usability & Acceptance Tests with Users
- Inspections based on Standards and Heuristics
- Data Mining of Usage Behavior and Analysis

Prototypes & Implementation
- Demos & Prototypes
- Technology Integration
- Product Solutions
- Technical Consulting

User-centered and iterative approach integrated into marketing & development
Introduction and History

From electromechanical instruments to mobile Computer Devices
INTRODUCTION

The Window to the Process

(Charwat, 1998)
Once upon a time …
… nowadays …
... and tomorrow
The Human operator
Human Information Processing

- Rasmussen’s model of human decision:
Human Information Processing

- Rasmussen’s model of human decision: Support of the human operator by the User Interface
Rule-based behavior

- rules about the interaction with the technical system
- rules are corresponding with well-known situations
- fails in rare fault situations - knowledge-based behavior is necessary
Mental Models

- Based on the system knowledge the operator forms a mental model of the system.
- A mental model contains the conceptions, which the operator formed regarding the functionality of the technical system.
- The quality of the interventions in the technical system by the operator depends on the correctness and quality of this mental model.
Mental Models

• Characteristics of Mental Models (Dutke, 1994):
  • Mental models have basically functional structure.
  • Mental models have strong pictorial-descriptive character
  • and can be promoted by pictorial means. (Dutke, 1994)

• Influences on mental models (Bainbridge, 1992):
  • Knowledge about task und goal, tools, system, training and experience

• Problem solving and action planning (Dutke, 1994):
  • Simulation with different initial values (possible actions)
    and state information
  • Optimization by changing the initial values
Mental Models

• **Necessary compatibility (Charwat, 1992):**
  1. between the real technical system und the presentation (UI)
  2. between the presentation and the mental model
  3. between the presentation and the interaction
  4. between different interaction devices
  5. between different presentation types of the technical system
Usability and User-centered Design
Definition of Usability

“Extend to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use.”

(ISO 9241-11)

**Context of Use**

- Users
- Tasks
- Equipment
- Physical and social environment

(ISO 9241-11)

**Dialogue Principles**

- Suitability for the task
- Self-descriptiveness
- Controllability
- Conformity with user expectations
- Error tolerance
- Suitability for individualization
- Suitability for learning

(ISO 9241-10)
ISO 13407

Need for user-centered design

Use-context

System meets all requirements

User- and organizational Requirements

UI Evaluation

UI Design
Use-context

• **user characteristics**
  • skills
  • experiences
  • mental models
  • etc.

• **tasks**
  • goal
  • frequency and duration
  • etc.

• **organizational & physical environment**
  • software
  • hardware
  • etc.
User- and Organizational Requirements

- satisfy laws & regulations
- support of workflows
- task performance
- interfaces between user roles etc.
- feasibility of service & maintenance
- etc.
User Interface Design

• use of knowledge from previous steps
• concretize design solutions from paper to functional prototypes
• check design solutions with end users
• etc.
User Interface Evaluation

- e.g. Usability tests
- typical end users
- typical task scenarios
User Interface examples

Research work
Example: Engineering portal

Model of the environment of an engineer

- Engineer
  - Cognitive abilities
  - Physiological abilities
  - Distribution
  - Requirements
  - Functionality
  - Data

- Engineering tools
  - Information interface 1..x
  - User interface 1..z
  - Data interface 1..y

- Tasks
Assumed Working Structure
Example:
Process Visualization for supervisory control

Design: Visualization of plant elements
Operators' description:
- „The sorter sifts out coarse fabrics.“
- „The sieves are baskets, like cans. “
- „working with holes or with slits“

Design: Visualization of plant elements
Example:
Process Visualization for supervisory control

VIRTUAL PROCESS ELEMENTS

Pump

P 111 OFF

P 111 ON
STATE AND GOAL VISUALIZATION

Fill-up Level

[Images of state and goal visualization in a cylindrical container]
SAMPLE APPLICATION
Distillation Column

Flowchart:
Example: Service & Maintenance

Actual Workflow of a Service Technician
Optimization Potentials
Requirements for Mobile Application

per mobilen Endgerät direkten Zugriff auf Prozessdaten, gleichzeitig unterstützt mobiles Endgerät Kommunikation mit Leitwarte

Dokumentationen sind über mobiles Gerät abrufbar

Dokumentationen:
- Wartungshandbücher
- Stromlaufpläne
- Explosionszeichnungen

Kopien/Notizen von Dokumentation:
- Wartungshandbücher
- Stromlaufpläne
- Explosionszeichnungen

Ja

Fehlerdiagnose durchführen

Nein

Abschaltung erforderlich?
UI concept for mobile devices
Thank you for your attention!

Carsten Wittenberg
SIEMENS AG – Corporate Technology
D - 81730 Munich/Germany
Tel.: +49 89 636 57470
Fax: +49 89 636 49428
E-Mail: carsten.wittenberg@siemens.com