User interfaces for embedded systems

– A brief course note –

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Contents

Chapter 1

Introduction

1.1 Practicalities

Welcome to the course on user interfaces for embedded systems. The present document outlines the main contents of the course; details will be provided during the course.

- Course load: 5 ECTS over 7 weeks
- Lecturers
  - Christian Fischer Pedersen, office E311, cfp@iha.dk
  - Stefan Wagner, office E304, sw@iha.dk
- Level: Undergraduate course
- Language of instruction: English (unless all participants are Danish)
- Literature
  - T. Tullis and B. Albert, *Measuring the user experience*, Morgan Kaufmann, 2008
    Companion website: www.measuringux.com
  - Other literature provided during the course

1.2 Course outline

Virtually all appliances and computers incorporate some sort of user interface. It is therefore important to achieve a theoretical and practical understanding of the design and implementation of these. Being successful in designing interactive products which support people in their everyday lives is crucial for many businesses.

The primary objective of user interface engineering is to construct and provide users with the best possible interface for machine interaction. What *best possible* means depends entirely on the given application and problem domains, but it is often desired to support users in achieving goals and accomplishing tasks in the most simple and efficient manner possible. Hence, user interface engineering is a user-centered discipline. The *machine* to be interacted with may be any kind of non-human construction, i.e. computers, kitchen appliances, tools, mobile communication devices, software applications, vehicles, etc. No matter the type of machine, the focus is on the user's perspective on the interaction pattern. In this particular course, the *machine* is any kind of embedded electronic computing system.

The field of user interface design for embedded systems is very large indeed and can not be adequately covered in any single course; this course will touch upon some of the field's core issues. Figure 1.1 illustrates a conceptual outline of the course.

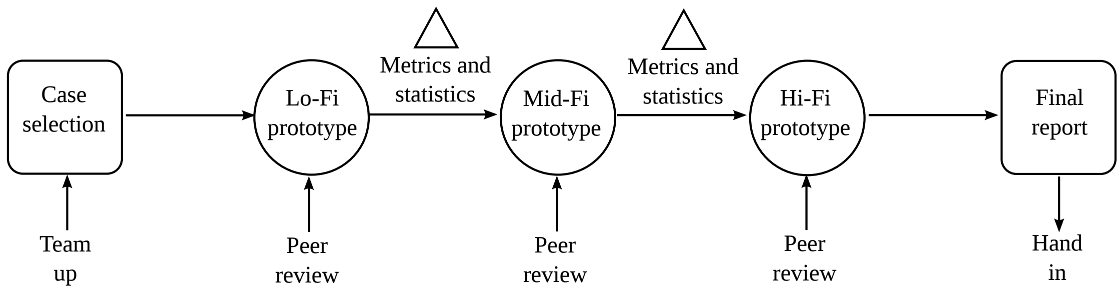

Figure 1.1: Conceptual outline of the course.

In the following sections the contents of the figure are detailed.

1.3 Case selection

1.3.1 Team up and define a project

In the beginning of the course, form teams of **four to six persons**. You decide among yourselves how to team up. Throughout the course, you conduct all your work, i.e. discuss and apply the course material in your projects, in the team. Each team is associated with a peer-team, i.e. a team that functions as an active opponent and discussion partner. Each team defines a project within the theme description, cf. chapter 4.

1.3.1.1 Peer team

All teams have a peer team assigned; peer teams are responsible for providing constructive feedback on each other's process and results. Especially at the peer reviews, peer teams must come together to provide feedback, discuss, and criticize constructively.

1.4 Metrics and statistics

Prototyping is an iterative process where the prototype is elaborated and refined gradually. When a prototype has reached a stage of high enough quality it may be matured further into a product. Clearly, it is important that the prototype actually becomes better and better through the iterative process. To ensure this, the quality of the prototype must be measured for each iteration; thereby, the quality improvements per iteration can be quantified. For the measuring part, software and user experience **metrics** are needed just as metrics are needed for physical quantities, e.g. length [m], time [s], and temperature [K]. In the course, software and user experience metrics are defined and exemplified. In order to quantify the quality improvements statistics are needed; this includes **descriptive** and **inferential** statistics.

In the course, examples of statistical calculations are done in either MathWorks' Matlab or a default installation of OpenOffice.org Calc, i.e. no statistical extensions are needed. Calc and Excel are quite similar, so you can use one or the other. As an introduction to OpenOffice Calc see e.g. the online book by Dana Lee Ling, "Introduction to Statistics Using OpenOffice.org Calc", College of Micronesia-FSM, 2010.

1.5 Low, mid, and high fidelity prototypes

In an iterative prototyping process a prototype goes through several stages; three of those are commonly in broad terms called **low-fi, mid-fi** and **hi-fi** prototypes where "fi" is short for fidelity. The three fidelity classes illustrates that the prototype is being **refined** through the prototyping process.

Low-fi prototyping

Low-fi prototyping is the very early stage of prototyping. At this stage, paper prototypes and mock-ups are commonly made. These prototypes are used by designers mainly to acquire feedback from prospective users about designs and design ideas early in the design process. Rather fix mistakes at this drafting board stage while it can be done with pen, paper, scissors, and eraser than later where you potentially have to redesign and rewrite code. Paper prototyping and mock-ups are widely used in software companies and supported by many usability professionals.

Mid-fi prototyping

Mid-fi prototypes are fairly detailed and complete, but objects are presented in schematic or approximate form. These prototypes often provide simulated interactive functionality and navigation.

Hi-fi prototyping

Hi-fi prototypes are high quality and semi to fully functional versions of the final product. However, any back-ends may still be simulated rather than real.

1.5.1 Peer review

In the peer review sessions you present your current prototype and project report to your peer group. You discuss each others work so far and gives constructive ideas to the work ahead.

Chapter 2

Project report structure

The report must adhere to the layout and general guidelines detailed below.

2.1 Layout guidelines

1. Front page
   (a) Title, team members, submission date, course name, institution name
2. Table of contents
3. Introduction
   (a) What is the project about, why is it relevant, how are you addressing the issue
   (b) Problem formulation: Prototype objective and usability/user experience issues

——— End: Initial report ———

4. Analysis
   (a) Current state-of-the-art and role-models
   (b) Common usage scenario (incl. context) and related use cases
   (c) Primary and secondary user groups and stakeholders
5. Low fidelity prototype, c.f. section 2.1.1
6. Mid fidelity prototype, c.f. section 2.1.1

——— End: Midway report ———

7. High fidelity prototype, c.f. section 2.1.1
8. Conclusion: Conclude with ref. to problem formulation and discuss perspectives
9. References: At least three. Must be high quality literature. Include the course book
10. Appendices, e.g. technical drawings, sketches, etc. (optional)

——— End: Final report ———

2.1.1 Layout guidelines for prototype sections

For each of the low, mid, and high fidelity prototype sections above describe:

1. The prototype with interaction devices and patterns. Include illustrations/pictures
2. Peer review session outcomes
3. Application of prototyping methods, materials, and acquired user data
4. Application of evaluation methods, metrics, and statistics

2.2 General guidelines

- Content: Stay within the defined theme, cf. chapter 4
- Length *all* included
  - Initial report max. three pages
  - Midway report max. eight pages
  - Final report max. ten pages
- Language: Danish or English
- Deadlines for hand in: See CampusNet | ITBFIS | Assignments
- Form: Format your report nicely and take care with spelling and punctuation

Chapter 3

Assessment

3.1 Prerequisites

Prerequisites for attending the exam

- Active participation throughout the course
- Prototypes
- A well written project report handed in on time. Both lecturers must receive:
  - A pdf file via CampusNet | ITBFIS | Assignments
  - A printed hard copy

3.2 Exam

About the exam

- The exam is individual, oral, and lasts approximately 20 minutes including voting
- Internal examiner
- Grading by the seven point scale
- No time for preparation
- The project report serves as a starting point for the exam. Based on the contents of the report, wider and deeper aspects of the syllabus is explored
- Bring your report to the exam
- Bring your prototypes - at least the latest one. The prototype(s) must be ready for display. We do not have time for setting up prototypes during the exam. If possible, set up your prototype in the exam room prior to your exam, e.g. in the morning
- It is allowed to bring notes
- Re-examination after appointment with lecturers

3.3 Exam sequence

As you have conducted your work in teams, the order of examination is also per team; specifically, the exam sequence is in ascending team number order. Teams decide the internal team member ordering; please decide in advance so no examinations are delayed.

As the study office does not know how the teams are composed, the guidelines above overrules the official sequence of examination made by the study office.

Chapter 4

Theme: Ambient assisted living for the elderly, diseased and caregivers

The essential idea behind the theme is to create user interfaces for ambient assisted living technologies that supports users in everyday situations. The assistance must be ambient, non-obtrusive, and have a touch of practical magic, i.e. a lot happens behind the curtain, but the user is only presented with intelligent and timely assistance. Do not make the users think, but wonder. **You must work with one of the cases described in this chapter.**

4.1 Automatic authentication

4.1.1 Primary user group

The primary user group of the prototype must include:

1. Care givers
2. Elderly
3. Disabled
4. Chronically ill

4.1.2 Primary stakeholders

The primary stakeholders of the prototype must include:

1. Care givers
2. Residents in, e.g. a nursing home
3. Family members
4. Emergency services
5. Housing and health authorities

4.1.3 Case background

The main functionality of Common Recognition and Identification Platform (CRIP) is the ability to

- Identify healthcare devices
- Identify and authenticate care givers by biometrics
- Communicate with other software systems

Focus should be on **usability** and **reliability**.

Care givers are to be identified and authenticated by biometrics, i.e. personal characteristics, features and traits, and devices are to be identified by, e.g. bar or QR codes. The biometric modalities, e.g. voice and fingerprint, may be fused, i.e. gathered information from multiple sources, to improve identification and authentification confidence. Also, fusing biometric modalities may prove as a foundation for **improved usability** as users may prefer to authenticate themselves via different modalities.

This leads to the following research and development topics

- Biometric modality fusion: Fusing data and/or features from different biometric modalities to improve security and authentication confidence. The security is enhanced as it is harder to trick/replicate more biometric modalities at once than just one. The authentication confidence is enhanced as more fusing information from more modalities will potentially lead to a higher certainty in person identification.
- Usability and interaction: The CRIP should be easy, fast and reliable to use. CRIP should be designed and evaluated with **user interaction** and **usability** in mind. Also, where should CRIP be located physically and how is data going to be gathered?
- Pesonalized configuration: It should be possible to configure CRIP based on the requirements of **individual users** depending upon what mode of biometric authentication is appropriate for the paticular user. The alternative biometric authentication modes provide flexibility for using the most suitable biometic authentication modes for citizens. Maybe all of this should just work automatically as we do not want to bother the user unnecessarily.
- User experirence/accesstability: We should perform experiements by involving users to observe how easily they can use the biometic authentication modes provided through CRIP. The user of different age group and different accessibility requirements can be selected for the experiments.

The prototyping work is therefore centered around: **Design and develop CRIP prototypes with interaction design methods. Test for usability**.

4.2 The smart home case

4.2.1 Primary user group

The primary user group of the prototype must include:

1. Elderly
2. Disabled
3. Chronically ill

4.2.2 Primary stakeholders

The primary stakeholders of the prototype must include:

1. Residents
2. Family members
3. Care staff
4. Emergency services
5. Housing and health authorities

4.2.3 Case background

The aging population has generated a significant interest by policy makers and industry leaders to develop home automatio'n systems for elderly, disabled, and chronically ill (EDCI) citizens. These systems focus on supportive and assistive technologies that enable the EDCI citizens to remain comfortably and safely at home. Due to drastic increases in health-care facility costs, more and more EDCI citizens turn to home automation, also known as *smart homes*, to allow them to live and age in the comfort of their own homes.

Smart homes allow EDCI citizens to stay in their homes where they feel comfortable, instead of moving to a costly health care facility. Relocating citizens to health care facilities often causes a lot of anxiety and home automation can either alleviate or delay this anxiety. Smart homes provide the opportunity for independence, which will help EDCI citizens to regain confidence, determination, and general quality of life.

Smart homes may be equipped with a range of different types of emergency assistance systems, security features, fall prevention, automated timers, and alerts. These systems allow for the individual to feel secure in their homes knowing that help is only minutes away. Smart home systems may also encompass remote monitoring of EDCI citizens and disease progression monitoring. For these systems to work, they very often integrate sensors for context sensing and microprocessors, mobile devices, and/or stationary computers for data processing.

Context sensing may include, e.g. in-door positioning and tracking, geographic orientation, acquisition and analysis of sound and ambient noise, acquisition and analysis of visible objects, and movement/acceleration. A common challenge is to synthesize context information in services and applications in a suitable manner. The sensors and microprocessors may be embedded in appliances, furniture, and clothing to ensure non-obtrusiveness of the services provided. In-house health networks may implement wired and wireless technologies to connect stationary and portable devices and store data in in-house and/or out-house health databases, e.g. electronic patient records.

Smart home technologies will, however, only be helpful if they are tailored to meet the individual needs of each citizen. Currently, many of the interfaces designed for smart homes are not taking the functional limitations of the EDCI citizens into consideration. The systems must be user-friendly as EDCIs often have difficulty operating electronic devices. The user interfaces - often multimodal in nature - must present the citizen with a minimal cognitive load and distraction. Also, privacy, data security, and user safety must be assured at all times, e.g. privacy may be addressed by biometric authentication or other data access control mechanisms.