

# User interfaces for embedded systems

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– A brief course note

## 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
- Lecturer
- Stefan Wagner, office E304, sw@iha.dk
- Level: Undergraduate course
- Language of instruction: English (unless all participants are Danish)

### 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 cannot 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.

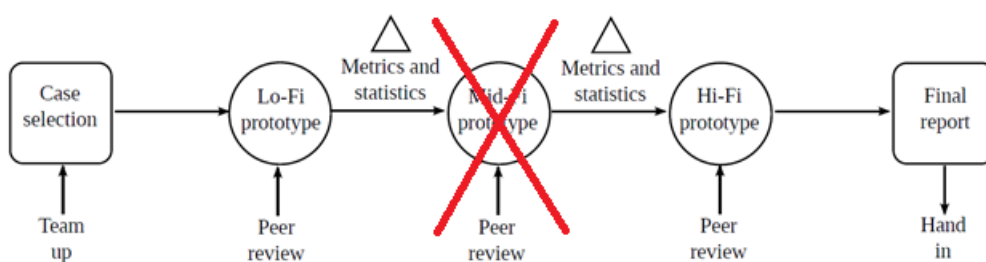


Figure 1.1: Conceptual outline of the course.

## 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 works on a project within the theme description, see chapter 4.

#### Shadowing, Diary, Scenarios and Personas

You will start with creating one or more scenarios to support the requirements of the project assignment. Next, you will use the method called “Shadowing” to follow one person in the age group 55-75 for four hours in the evening, and four hours in the morning on another day. Shadowing means that you will follow your subject around in his or her home, to get an understanding of the activities that they usually perform. Also, you will ask these users to keep a Diary for three days each, describing which daily activities they undertook. Make sure that you get them to sign an informed consent form, as we shall use the data in a scientific study. It is ok to involve friends, family (parents, uncles, aunts), neighbors etc as test subjects.

We shall use your findings to inform your project user interface design, and you will test your prototypes with the same users at a later point.

Next you will identify stakeholders (based on your field work doing “Shadowing” and “Diary”, and from your project description), and create “Personas” for the user types identified, again based on Shadowing and Diary. These “Personas” are useful when designing user interfaces.

#### 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. Also, peer teams shall test each others' prototypes with their respective test subjects.

The members of your peer team are required to help you during your test sessions. There will be some time available for testing during class – but you should also be able to meet at other times.

## 1.4 Metrics and statistics

The course and project focuses highly on “Prototyping” as the preferred design and research method. 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 Microsoft Excel, 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.

You are expected to simple descriptive statistics, including calculating a mean, as well as a standard deviation, e.g. logging “time on task” – how long time a user spent solving a given task. These figures you can then compare to your other prototypes – and maybe even to your peer groups.

## 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, or quality. 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. You will create at least two low-fi prototypes that uses a different design approach – in order to compare these. You may also compare with your peer groups if feasible. The low-fi prototypes might not contain all of the features of the specified scenario. It is more important to take the time to do the exercise evaluations than have a comprehensive system.

Please review the 10 Jakob Nielsen heuristics (see page 506-507), and use them along the 5 touch screen guidelines to create a checklist.

Use Heuristic Evaluation to uncover errors in your two low-fi prototypes, and compare these two to each other. Let your peer group do a review on your two prototypes. Compare their findings with your own. Use the 10 guidelines

Make a proper report where you compare the two prototypes, then let your peer group do the same, where each peer-group member only reviews one of your prototypes.

**Compare the two prototype evaluation reports made in your group with the reports made by your peer group. Write a ½ page report and prepare a 5 minute presentation. Which of the prototypes contained the most errors? What was the error about? Did different observers find the same problems when going through the checklist?**

### 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. Again, at least two prototypes with different design decisions in order to compare. Here, you may consider to primarily compare qualitatively, but may also consider using performance metrics – such as time on target – or issues. In 2015, due to time constraints, you are not required to complete mid-fi prototypes.~~

### 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. Again, at least two prototypes with different design decisions in order to compare. Here, you may use qualitative methods, as well as quantitative performance metrics – such as time on target – or issues. At least provide descriptive statistics on a range of tasks or entire scenarios.

On your two (or three) Hi-Fi prototypes, apply Think Aloud on at least four of your end-users, try using Wizard of Oz on at least one, and make a Video prototype. Record on video and document the applied methods on ½ page each.

### 1.5.1 Peer review

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

## 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), personas (and optionally 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 BB | ITBFIS | Assignments
- Form: Format your report nicely and take care with spelling and punctuation

## 3. Assessment

### 3.1 Prerequisites

Prerequisites for attending the exam

- Active participation throughout the course
- Mandatory multiple choice questionnaires must be passed
- Prototypes must be completed and approved by peer group
- A well written project report handed in on time. Must consists of:
- A pdf file via Blackboard (international students: December 19<sup>th</sup>, Danish students: January 10th)
- A printed hard copy (bring to the exam including your initial lo-fi prototypes!)
- The report will not be edited by the teacher – but you may ask for feedback during class and exercises

### 3.2 Exam

About the exam

- The exam is individual, oral, and lasts approximately 15 minutes plus voting
- Internal examiner (will not read the project before starting)
- Pass or failed (7 scale for international students)
- No time for preparation
- A list of 4-6 questions will be made available before the exam for which you should prepare a 5 minute presentation for each
- The project report serves as input for the last 5 minutes of the exam – but the exam will have the form of an interview, asking questions in the syllabus. 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 guideline above overrules the official sequence of examination made by the study office.

## 4. Project Theme: Ambient Assisted Living Reminder System

The essential idea behind the theme is to create a user interface for ambient assisted living (AAL) technologies that will support senior citizens in their own home to live more independently from help, and keep them longer out of hospital and care facilities.. **You must work with this case. You must construct two prototypes for each level, where you have clearly stated what alternative design decisions you have made, and why. When you do the evaluation, these design decisions are then tested up against each other. Each test user is randomized to either start with prototype 1 or 2, and you will use the methods of the course to evaluate each prototype approach. In 2015, we have removed the mid-fi prototyping session, as one week is removed from the course. You may still produce a mid-fi prototype, but this is not mandatory.**

### 4.1 Automatic authentication

#### 4.1.1 Primary user group

The user group are Care givers (trained home nurses)

#### 4.1.3 Case background

**A home care system is to be developed for supporting the residents ability to remember appointments, training, and taking medication.**

**The main scenario to implement is:**

“A senior citizen, Hans Jensen (replace name with your own persona), is made aware by the AALSystem of a range of *tasks* that needs to be done, of which the first, taking medication before breakfast is critical to resolve before breakfast. Next, Hans Jensen needs to measure and enter blood pressure and weight data, as well as doing morning exercises. Also, there is a reminder to write an email to his daughter. Of these, some are within a given time-range – e.g. before a “latest date” – and some are critical or important (see list below). Hans Jensen is guided to solve the critical tasks first, then the important ones, and then he solves one of three or more “latest date” tasks. The device used is a touch screen computer where access is granted by using a fingerprint reader or RFID/NFC card, or alternatively via a manual login screen (three different scenarios). Before Hans Jensen logs in, the device will act as a picture frame viewer, showing pictures of Hans Jensen’s children and grandchildren, as well as various picture art that he likes in a full screen slide show application. The touch screen computer is mounted on the wall in the home of Hans Jensen. Hans Jensen leaves the device to perform the blood pressure and weight measurements, and to take the medication – and comes back to enter these data after it is done.

The list of tasks are:

Critical

1. Remember to take morning medication

Important:

2. Measure blood pressure and weight, and enter these manually into the system
3. Do the morning exercises and verify this

Solve before latest date (she will have time to perform one of these in your scenario):

4. Open the windows for 20 minutes and verify this.
5. Activate the robot cleaner and verify this.
6. Check calendar for upcoming events
7. Write a message to daughter Hanna, that he needs to be picked up later in the evening for a visit

## **Student data gathering activities**

Each group needs to find one male or female for each group member in the age group 55-75 to include in their study. Thus, if you are 4 group members, go for two male and two female in the age group. For each participant record:

The participants will be involved in your project at various stages.

An informed consent form must be filled out (will be provided by teacher). The findings will be used anonymously for scientific projects, by your fellow students, and researchers.

First, each student will undertake a qualitative field study, and gather data to increase your understanding of how your AAL system could best support them, and what they would wish the system to support them with.

You will undertake a field study including the observation technique Shadowing, where you will spend 4 hours during a week day, and 4 hours during a weekend, recording all activities that the participants are doing (form will be provided by teacher).

Then, participants will be asked to keep a Diary, for 3 days, where they take notes and/or take pictures of things they would like to have help with, e.g. "I would like a robot cleaner", "I would like help with taking out the trash", "I would like help with reminding me of appointments", "I would like the system to remind me to take my medication", "I would like to keep track of my weight", etc. It is most important that you explain the purpose of the reminder system to them before starting, but after the Shadowing part, and that you explain that different types of interfaces are possible: sound, voice, screen, touch, etc.

Finally, the participants will fill out a questionnaire, that we shall develop on class together, and where the data will be collected, and shared with other students and researchers anonymously.

Prepare a report on the findings from the field study and the questionnaire, and keep documentation in the shape of notes and audio recording etc.

Based on the field work, you will adapt the provided scenario slightly, and you will develop two Personas, one for each of your participants. It must not be those two participants that you describe, but they may share relevant features. It is up to you to consider different types of user interfaces to use for the reminder, and then test the different UI types against each other.

Based on the field work, the scenario, and the personas, create the first lo-fi prototype, and test it with the participants. Document the results and propose changes for the next prototype.

Finally, create a hi-fi prototype, based on the previous findings, and test it with your test subjects.

Follow the detailed time schedule as outlined on Blackboard course page.