Biomedical and hospital informatics
Master 1

Human Machine Interface
Interface Homme Machine
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Mrs HamzaCherif Souaad

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Chapter 4 : Design and evaluations of HMIs

1. Introduction

1. Introduction

- Any software engineering design, whatever the model (V model, spiral, etc.) used, should strongly involve the user upstream and downstream of the project (from needs analysis to evaluation) in order to guarantee usability of the product.

- However, some Methods are system-centric: the functionalities are put to the detriment of the users which is a factor of failure because the HMI must be thought of from the analysis phase of the concrete Artefact software which will be used by the users.

1. Introduction

- There are several examples of bad practice of HMIs in the history of designs especially in critical systems, we can cite the Airbus disaster (1992) where there was confusion in the display of units on an altimetry dial , which caused the plane crash or the Three Mile Island nuclear accident (1979) due to the fact that the human dimension had not been taken into account in the supervision process

1. Introduction

- Studies have also shown that 67% of maintenance requests are due to changes requested on the HMI. Consequently, HMIs must be thought of from the analysis phase, and in this context it is necessary to have design and evaluation dedicated to HMIs.

- They have a significant impact on the attractiveness of the software, productivity gains and development, maintenance and training costs.

2. HMI Design Methods

- Adopting HMI design methods in the design of computer systems aims to reduce software development and maintenance costs, risks, and also increases productivity gains on the user side.
- There are different ones in the field: **iterative design, design by prototyping, user-centered design, participatory design, informative design, and design by personas and scenarios.**

2. HMI Design Methods : Iterative design

- **Iterative design**

- This method involves a succession of phases, where we will gradually refine the product specifications, and we evaluate the solutions retained.

- The HMI is then modified until a satisfactory product is obtained. This type of construction process requires communication between the design team and the user.

- It is generally used for problems that are difficult to specify because it is neither ascending nor descending, it is rather a development of partial, intermediate solutions where new objectives can appear during development, especially as user opinions which can change

2. HMI Design Methods : Prototyping

- **Prototyping**
- Prototyping is the process of building a prototype. A prototype is an incomplete example of what the final product should be.
- This approach allows designers to work on several sets of details at once and users to see what the final system will be. This way, we can easily identify problematic parts of the interface and study design alternatives to ensure the usability of the system.

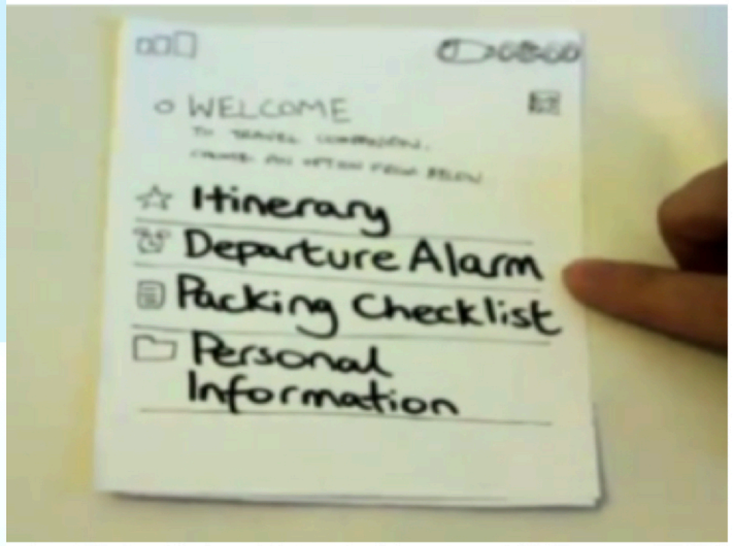
2. HMI Design Methods : Prototyping

- There are different types of prototypes that a designer can use:
  - Informal prototypes, on paper:
    - This approach simply consists of drawing screens on paper, on software. You can use post-its, transparencies, or presentations for dynamic montages
  - Video prototypes
    - This involves creating a video of the use of a prototype. We can also simulate non-implemented functionalities and interactions.
  - Computer prototypes using tools:
    - In this case we use dedicated software which either allows direct access to the interface (example Visual Basic, Delphi), or which can assist the designer with prototyping (example Visual C , Tcl-Tk, Pencil).

2. HMI Design Methods : Prototyping

- Any prototyping requires taking the user into account before the evaluation phase and combining information collection techniques (interviews, questionnaires, etc.)

2. HMI Design Methods : Prototyping



Paper prototype

Software prototype

2. HMI Design Methods : User-centered design

- This method, as its name suggests, takes the user into account from the design phase. The designer must observe the user in solving his task, question him about his expectations, question him about the software designed. This method has three phases:
  - **Analysis** (identification of functionalities or services, i.e., the usefulness sought by users of the application)
  - **Development** (construction of the menu structure and division into windows, web pages, etc.)
  - **Evaluation** (progressive refinement of the prototype)

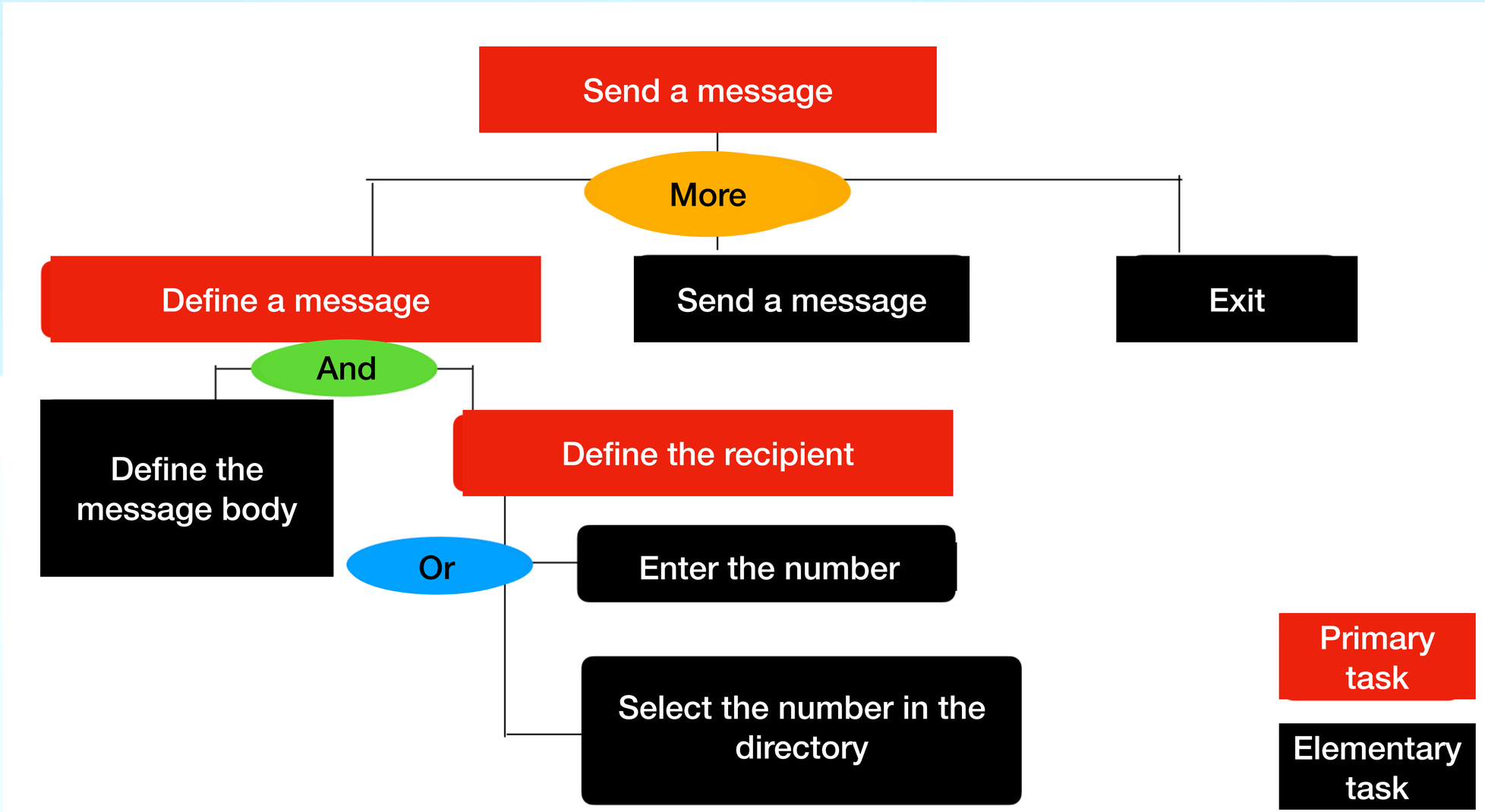
2. HMI Design Methods : User-centered design

- In this case, it is necessary to specify the characteristics of the 3 elements of the HMI: the user, the task to be carried out, the interaction:
  - **User model:**
    - identify relevant user characteristics.
    - It includes general user data such as: height, age, gender, impairments, education level, cultural habits, and data linked to the application: skills in the field and in IT (beginner, occasional, experienced, expert.

2. HMI Design Methods : User-centered design

- **Task model:**
  - A task is characterized by a goal and a procedure to follow to achieve it.
  - The procedure is made up of a set of subtasks linked by composition relations or temporal relations.
  - A task can also be elementary, i.e. decomposable only into physical actions I/O operations. The task model aims to identify the sequence of processes of a task and construct the task hierarchy of the system.

2. HMI Design Methods : Example task template



2. HMI Design Methods : User-centered design

- **Interaction model:**
  - it consists of establishing a direct correspondence between:
    - conceptual computer objects (example: a file)
    - interaction and presentation objects
    - the representations of the file on the screen (closed, open)
    - operations on the file (modification, deletion, etc.)
- This correspondence must appear natural and be part of an overall coherence through the metaphor of using concepts known to the user, for example using icons (house, printer, mail, etc.)

2. HMI Design Methods : Participatory design

- In this case, users are not only taken into account as testers but also as design partners, obviously for tasks essentially known to users, which can be a possible source of innovation.

- This method has the advantage of facilitating acceptance of the software, but. Can also create possible contradictions between participating users, hence the obligation to make compromises to satisfy users even if they are wrong.

2. HMI Design Methods : Informative design

- This is a method generally used for the design of systems dedicated to children. In this case, taking users into account is halfway between testers and design partners.

- Generally speaking, the user is considered in the design team but does not participate in the final choices.

2. HMI Design Methods : Personas and scenarios method

- The Persona Method is used in different fields (marketing plans, surveys, etc.), it was introduced in the early 1990s for the design of HMI. It consists of defining a persona and writing a scenario (like in the films).

- The persona (or archetype) is not a real user, but an abstraction of several users which brings together the most frequent characteristic traits of users. Thus we can have a better understanding of users and their goals thanks to the shared vision of users.

2. HMI Design Methods : Personas and scenarios method

- The description of a persona can include:
    - Objectives, constraints, work environment
    - What will trigger their actions
    - What can influence them
    - What can slow them down or make them flee
    - A first name
    - A title
    - A photo
    - A currency (in relation to the application)
    - A description, education, social background

2. HMI Design Methods : Personas and scenarios method

- A scenario is a kind of story with: a persona, an environment, a goal (that the persona must accomplish), and obstacles. The execution of a scenario can guide the designer in the choices of functionalities, interactions, interfaces.

- Example scenario Connect to the YouTube site, search for videos by title or performer, add it to a playlist, then turn off your playlist.

3. Information gathering techniques

3 Information gathering techniques

- Most HMI design methods require collecting information about users and their activities

3 Information gathering techniques: Design scenarios

- The goal here is to create a realistic description of the use of the new system by using storyboards from the world of cinema in order to have an overview of the interaction.
- It is necessary first of all to identify existing activities (typical or unusual) and then to create work scenarios by generalizing the stories using example events which consist, for example, of:
    - mix events from different sources
    - incorporate unusual situations into typical activities
    - include situations that succeed and others that do not

3 Information gathering techniques: Cognitive inspections

- This method aims to evaluate the system by putting oneself in the user's place by specifying a series of tasks and sequences of actions to carry them out.

- The designer must imagine and interpret what the user would do, and evaluate his system from there, for example: does he understand the messages, the behavior of the system?.

3 Information gathering techniques: Wizard of Oz

- This technique is difficult to implement, it is rather suited to heavy systems that are difficult to develop.
- It consists of simulating functionalities absent from a real, non-existent or partially developed system.
- In this case an accomplice carries out the actions in place of the system. After which the “magician” interprets the user inputs, he then makes up for the shortcomings of the prototype and controls the behavior of the system.

3 Information gathering techniques: Survey / interview

- The goal is to identify design ideas for future iterations or specific examples of problems encountered by users by interviewing them in their work environment (face to face, recommended duration of 45 minutes / one hour).
- It is also possible to use interviews for critical incidents, by knowing how to ask the right questions to the user:
  - Ask to remember a particular problem experienced in the recent past — Ask to describe each incident in detail
  - Ask what is usual and what is not usual in the incident

3 Information gathering techniques: Observations

- This aims to identify major problems with the software (prototype/ system), by observing users in the field. It is then necessary to define a specific mission (solve a problem, follow a scenario) of what we want to measure.

- Users are then asked to carry out the task (intrusive method) and their interaction is observed.

3 Information gathering techniques: Focus group

- This method consists of forming a group of 7 to 10 participants and defining different themes to address (5 or 6 recommended) relating to specific points of the interface.

- This confrontation and discussion between the group can bring out new ideas and help the designer to have an overall vision of the system in terms of motivations, preferences, priorities, expectations, and even conflicts.

3 Information gathering techniques: Questionnaire

- The aim of this method is to economically summarize the opinions of many users. To do this, it will be necessary to determine the (representative) public receiving the questionnaire, and also see how to distribute and retrieve it.

- Questions can be General Information, open questions, guided questions, multiple choice questions, or ratings and rankings.

3 Information gathering techniques: Brainstorming

- This involves generating a large number of creative ideas by bringing together a small group with different roles and expertise. From there we describe a specific design problem.
- This method has two phases: during the first it is a question of generating a large quantity of solution by involving all the goure and by recording all the ideas without evaluating them.
- Phase 2 consists of sorting and classifying the ideas by participants' votes, the one which will have the more voices will be selected.

3 Information gathering techniques: Parallel design

- This consists of creating several interfaces and selecting their strong points using a representative panel of users where each user (or group) independently creates an interface (paper, software, etc.), and at the end it will be necessary to evaluate and discuss the interfaces carried out.

3 Information gathering techniques: Ergonomic audit

- This involves quickly evaluating an interface by ergonomics experts. Ideally by several independent experts and we compare their results. Either by an ergonomics expert and proofread by an expert in the field.

- But in this case you will have to think about the cost of the audit, and there will be no feedback from the end users of the application.

4. HMI evaluation approach

4 HMI evaluation approach

- Evaluating the HMI means verifying that the system is usable. A system is said to be usable if it allows the user to carry out their task with effectiveness, efficiency and satisfaction in the specified context of use (ISO 9241-11 standard):
  - **Effectiveness:** Check that the objectives set by the user are achieved.
  - **Efficiency:** Measuring the resources needed to achieve these objectives (e.g. time, errors, etc.).
  - **Satisfaction:** Determine whether the system is pleasant to use.

4 HMI evaluation approach

- There are several evaluation approaches in the literature. They are classified into two categories:
  - **Analytical approaches (expert-based)**: examines the HMI according to heuristics, ergonomic criteria, cognitive path.
  - **Empirical approach (user-based):** uses metrics, scenarios and tasks to directly observe users and analyze data.

4 HMI evaluation approach : Analytical approaches

- Analytical approaches aim to control the quality of the interface according to a model defined a priori: this model can be either :
    - informal (personal learning of the profession, evaluation grid),
    - or formal (predictive models, models quality of the interface).

4 HMI evaluation approach : Analytical approaches

- **Informal methods**

- These approaches are based mainly on the expertise or knowledge of the expert without a priori involving the user in the evaluation,

- It involves applying the guidelines during the design as well as the verification of the prototype.

- It is possible to use personal learning of the profession or evaluation grids

4 HMI evaluation approach : Analytical approaches

- **Personal learning of the profession:**
  - It consists of the evaluator putting himself for a time in the place of users and learning their profession. it should be excluded when the tasks are complicated, it is rarely useful, the evaluator tends to take himself as a model, can only become an inexperienced user, and therefore experience difficulty in objectively analyzing the work.
  - However, for simple tasks where the evaluator is in fact a potential user (for example in office automation), the implementation of the method entails fewer difficulties and in any case allows at least the evaluation of the support system hand.

4 HMI evaluation approach : Analytical approaches

- **The evaluation grids:**
  - It aims to assist the evaluator by listing parameters characterizing the ergonomics of an interface.
  - For each of these parameters, the interface is systematically rated according to a scale comprising several points.

4 HMI evaluation approach : Analytical approaches

- **Formal methods**
  - Predictive formal models: are gradually developed, starting from the hypothesis that certain user performances can be predicted, and therefore considered when designing the interface Example:
    - **The GOMS model (Goal, Operator, Method, Selection)**, makes it possible to model user behavior at different levels of abstraction, from the task to physical actions in terms of goals, elementary actions, methods for achieving a goal and rules for selecting methods.
    - **The Keystroke model is derived from GOMS.** It concerns the physical actions of an expert user when performing a task. It aims to predict the execution time of a task. Typically, it inherits the advantages and limitations of GOMS.

4 HMI evaluation approach : Analytical approaches

- **Formal methods**
  - **Formal models of interface quality.** These are interested in the measurable properties of the interface, from a less task-oriented point of view than previous models: they are much more focused on the presentation of information.

4 HMI evaluation approach : The empirical approach

- This type of approach makes it possible to evaluate the ergonomics of the interface based on the collection and analysis of data from its use by users representative of the final population, and this in an evaluation environment as close as possible to that of use.

- Two approaches are distinguished: design tests, usage diagnosis,

4 HMI evaluation approach : The empirical approach

- **Design tests:**
  - This type of evaluation can be implemented a priori when there is no experience using the system yet. Tests are then carried out throughout the design process

4 HMI evaluation approach : The empirical approach

- **Usage diagnosis:**
  - It is most often carried out a posteriori when there is aexperience using the system as a whole. Six techniques, presented successively, make it possible to diagnose functions or modes of representation that are faulty, useless, difficult to exploit, etc.

4 HMI evaluation approach : The empirical approach

1. The critical incidents method:

- It consists of systematically collecting the malfunctions of the man-machine system based on interviews with users and observations carried out at their workstation. Each incident is described in the form of a short story.

2. The user questionnaire:

- Allows the evaluator to collect subjective information in a secure and structured form, conducive to analysis.

4 HMI evaluation approach : The empirical approach

3. Monitoring, or electronic tracking:

- Allows objective data to be automatically collected using the computer. This method can inform the evaluator about the activities and performance of a user, whether in a real situation or in simulation.

4. Analysis of traces written by the user during work:

- It facilitates the identification of use problems (reports which describe events that occurred, faults, shutdowns, restarts, etc.)

4 HMI evaluation approach : The empirical approach

5. Analysis of eye movements:

- Based on the study of oculomotor activity, we study the way in which the user searches for and locates useful information in depending on the different situations, in order to identify gaps in the interface.

6. Workload:

- It’ s a useful quantity for evaluating human-machine interfaces. It consists of evaluating to what extent graphic tools influence their workload.