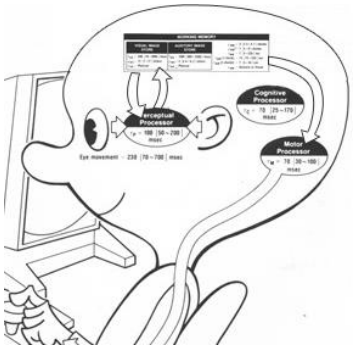
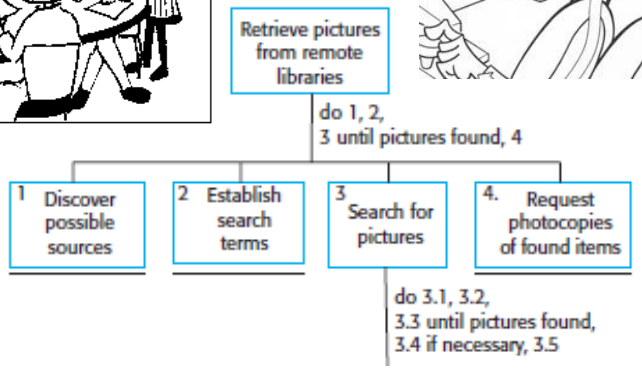
Universidade de Aveiro
Departamento de Electrónica,
Telecomunicações e Informática

Other models for design and evaluation





- All engineering fields use models:
  - To prescribe – directly contribute to the design
  - To evaluate – does the design have the needed characteristics?

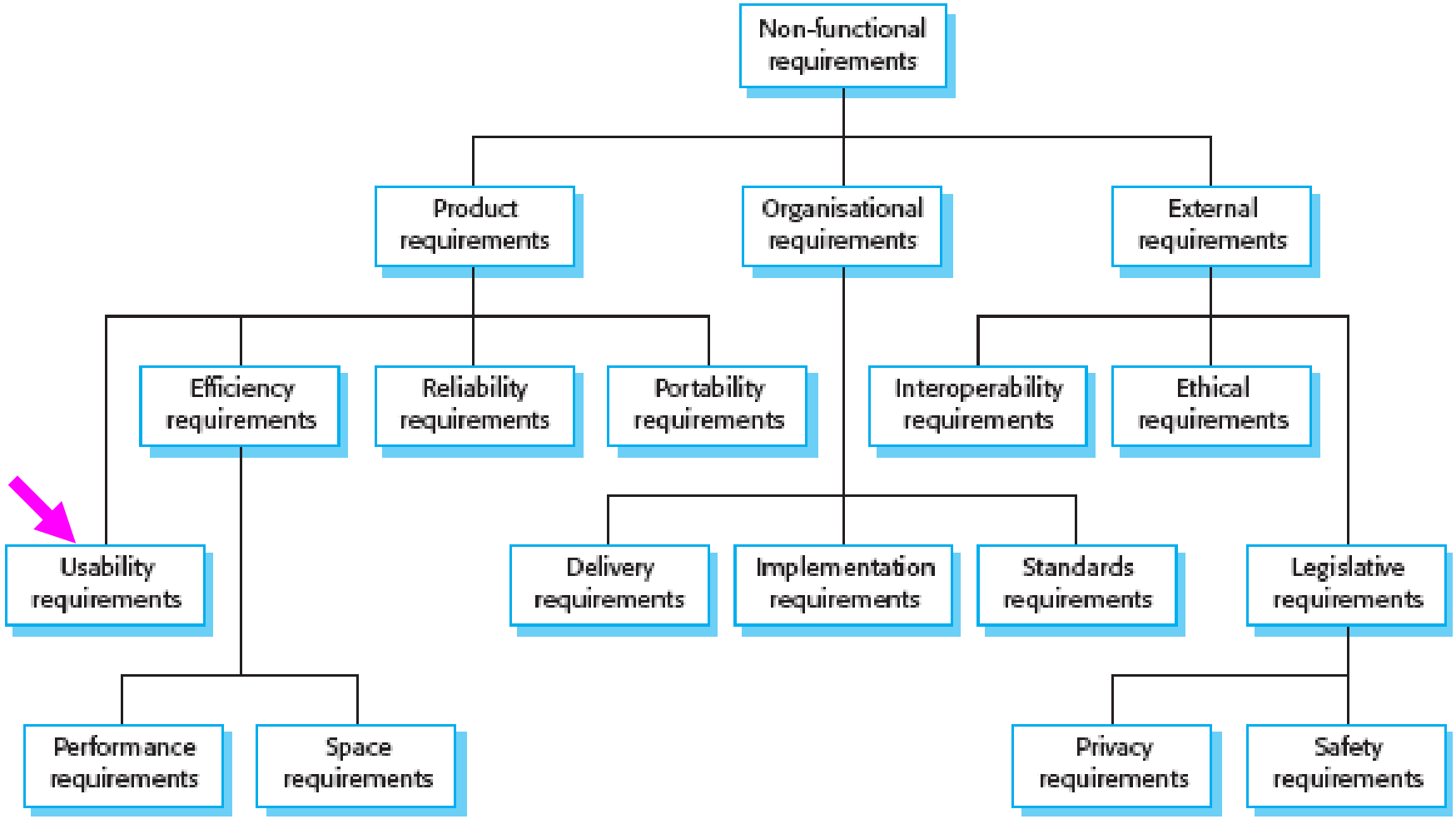
- Models are needed also in Interactive systems design (you already know and have applied a few…)

- Several types of models may be used throughout the design of interective systems and user interfaces:
  - User models
  - Task analysis
  - Dialog notation
  - …

Models to obtain user requirements

- Obtaining user requirements is very important in S/W engineering
- But often focuses on functional requirements: what the system must do
- Overlooking non-functional requirements, as if it is:
    - acceptable
    - usable
- There are several models to capture user requirements

Non-functional requirements



(Sommerville, 2016)

Models to obtain user requirements

- *Socio-technical models* - acknowledge that technology is used within an organization

- *Soft System methodologies*- put the emphasis on the understanding of the situation and not on getting a solution

- *Participatory Design* – encompasses the complete development cycle and includes users as active project team members, not only as evaluation participants

Participatory design

- Users are involved as domain experts (e.g. business representatives and users) along the complete process and work together with developers to design a solution
  - It is work oriented and not system oriented
  - It is collaborative- users contribute to all phases
  - It is iterative – design is evaluated and reviewed in every phase

Participatory design

- Uses a set of techniques (that can be used in other contexts) to help transfer information from users to designers:
  - Brainstorming
  - Scenarios
  - Story boarding
  - Workshops
  - Paper and pencil exercises ...

https://www.usabilitybok.org/participatory-design
https://www.usabilityfirst.com/usability-methods/participatory-design/index.html

Task analysis

- What it is and how it can be performed (more or less formally)

(Note that in Lab classes we started by doing it in an informal way…)

- Techniques

- Sources of information

https://www.usabilitybok.org/hierarchical-task-analysis
https://digital.ahrq.gov/health-it-tools-and-resources/evaluation-resources/workflow-assessment-health-it-toolkit/all-workflow-tools/hierarchical-task-analysis

Task analysis

- It is the analysis of how people perform their work
  - what they do
  - what they use
  - what they need to know

- Daily-life example: vacuum cleaning a house

  Get the vacuum cleaner
  Choose the adequate attachment
  Clean the rooms
  Empty the bag when it is full
  Put the vacuum cleaner and attachments away

  Users have to know about vacuum cleaners, rooms, …

Task Analysis

- Observation (of various types) is a fundamental tool

- It can be used to:
  - produce documentation and training materials
    (the observation of how existing
    systems are used is enough)

  - design new systems
    (work-re-engineering is usually necessary)

Task Analysis approaches

- There are a lot of approaches and methods; we have used an informal way in the practical classes, but there are more formal methods
  - Task decomposition ✓
  - Knowledge based
  - Relation and entities based

- We have used an informal way in the practical classes, but there are more formal methods

  - Task decomposition - divides tasks into subtasks that must be performed in a specific sequence

  - Knowledge based – considers what users need to know about the objects and actions involved in performing the task and how knowledge is organized

  - Relation based - is focused on actors and objects, relations among them and the actions they perform

Task Decomposition

- Hierarchical Task Analysis (HTA) is one of the most used task analysis techniques and produces:

  - a task and sub-task hierarchy

  - plans with a sequence and execution conditions

Simple daily life example: vacuum cleaning the house:

0. in order to clean the house
    1. get the vacuum cleaner
    2. fix the appropriate attachment
    3. clean the rooms
        3.1. clean the hall
        3.2. clean the bedrooms
    4. empty the dust bag
    5. put the vacuum cleaner and attachments away

Plan 0: do 1 – 2 – 3 – 5 in that order
when the dust bag gets full do 4

Plan 3: do any of 3.1, 3.2, or 3.3 in any order depending on which rooms need cleaning

Plan 3 could be more specific; what if it were varnishing the house?

- Where should the decomposition stop?

- The decomposition detail depends on the goals of each task analysis

- Example: in a factory what should be done in an emergency

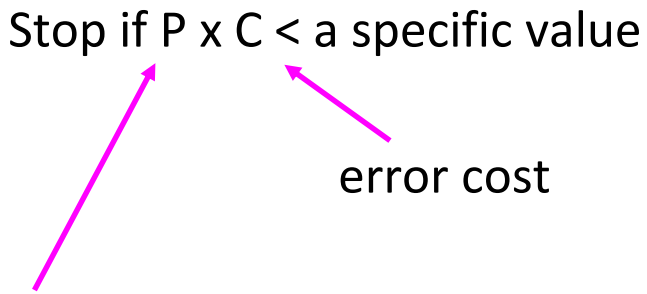
  0. in a emergency

     1. Read the alarms
     2. Determine the corrective actions
     3. Execute the correction actions

- If the goal is
  - installing a monitoring system → expand 1 e 3
  - produce operation manuals → expand 2

- Where should the decomposition stop?

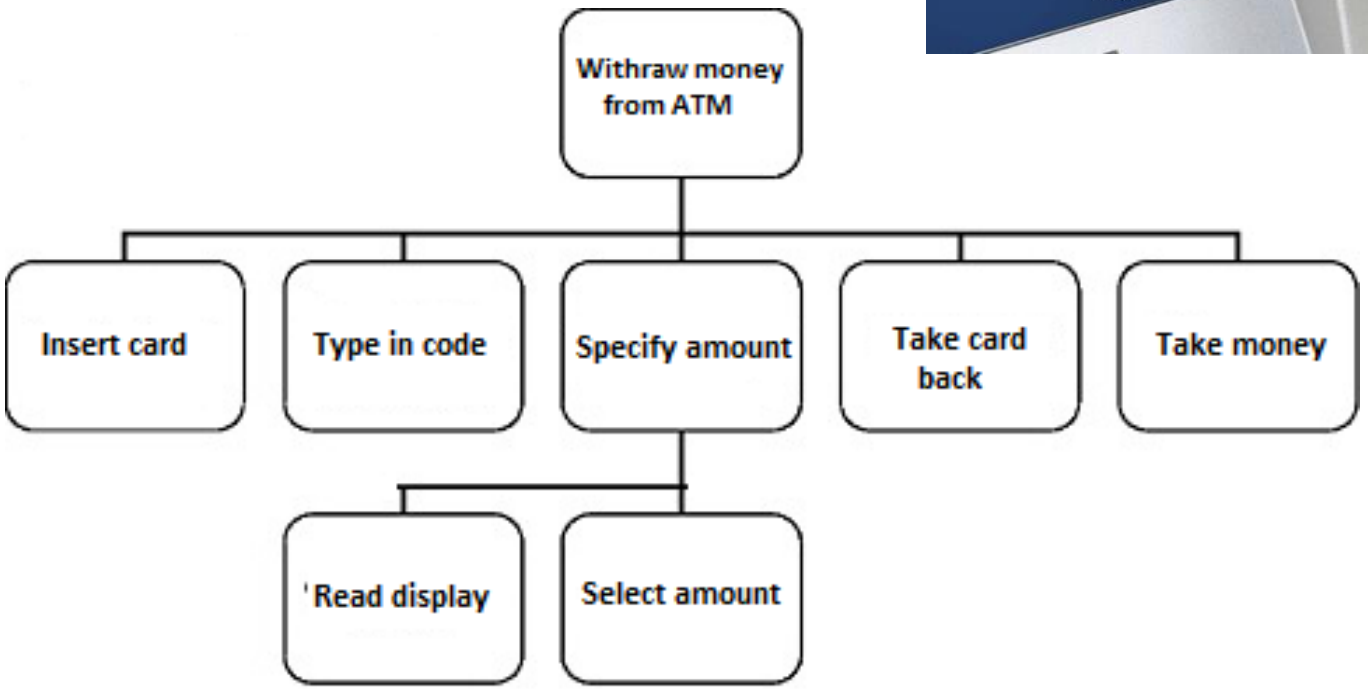
- A stop decomposition rule:



i.e.: simple tasks do not need decomposition unless they are critical!

Incomplete decomposition of the task:
Withdraw money from an ATM

Can you fix and complete it?



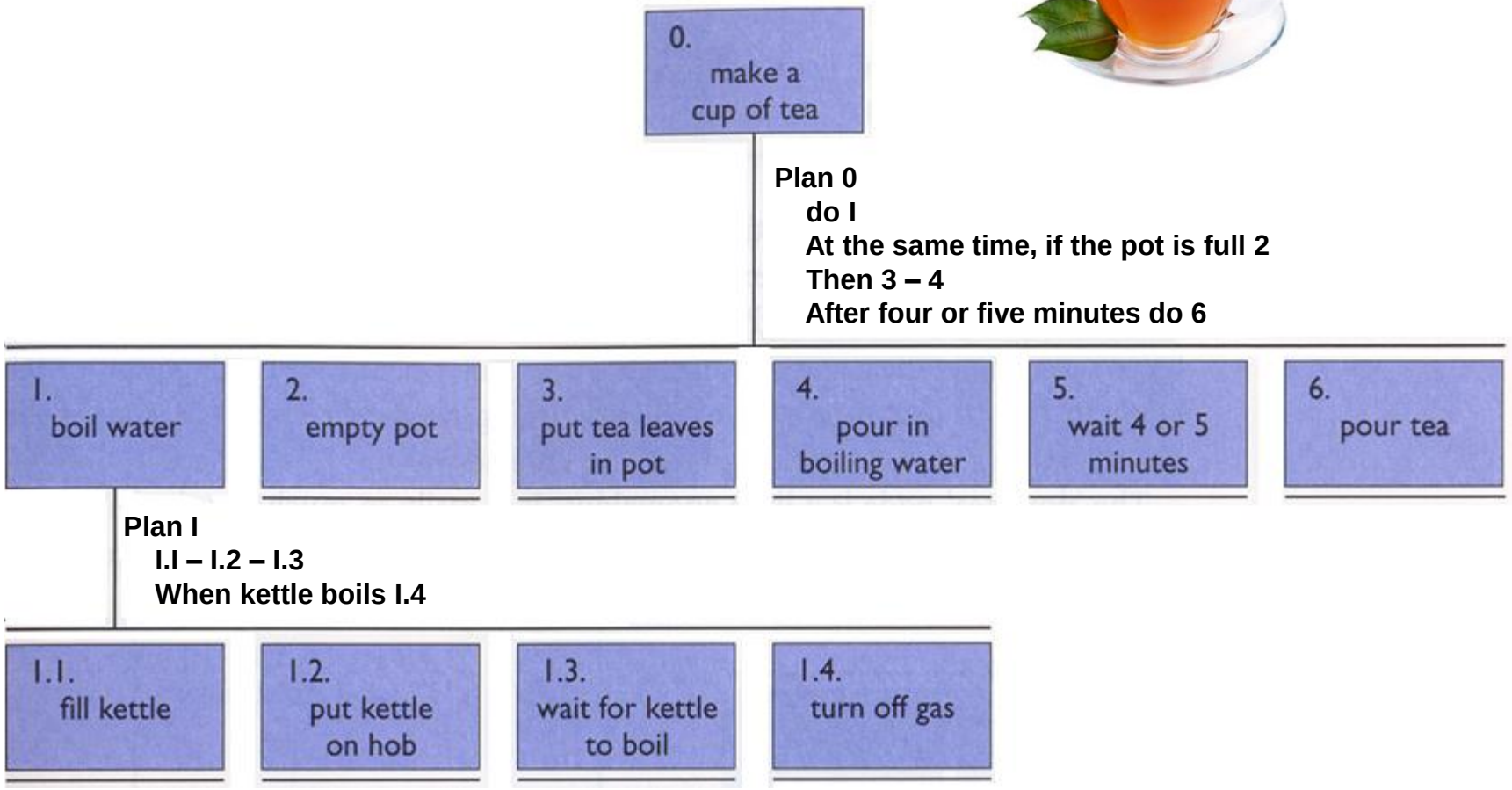
Another daily life example:

Preparing a cup of tea

Can you do a HTA describing this task?

HTA- Preparing a cup of tea

(graphical representation
of first approach)



HTA- Preparing a cup of tea
(analysis of the of first approach)

Do we want only one cup of tea?

??

0. make a cup of tea

Plan 0
do 1
At the same time, if the pot is full 2
Then 3 – 4
After four or five minutes do 6

Warm the teapot is lacking

1. boil water
2. empty pot
3. put tea leaves in pot
4. pour in boiling water
5. wait 4 or 5 minutes
6. pour tea

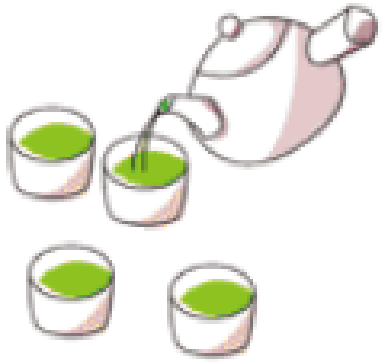
Plan 1
1.1 – 1.2 – 1.3
When kettle boils 1.4

1.1. fill kettle
1.2. put kettle on hob
1.3. wait for kettle to boil
1.4. turn off gas

Is it this simple?

Turn on the gas?

HTA- Prepare several cups of tea (a new hierarchy)



Restructured task

0. make cups of tea

Plan 0
do I
At the same time, if the pot is full 2
Then 2 – 4
After 4 or 5 minutes do 5

New sub-task

More complex sub-task

1. boil water
2. empty pot
3. make pot
4. wait 4 or 5 minutes
5. pour tea

Plan 1
1.1 – 1.2 – 1.3 – 1.4
When kettle boils 1.5

Plan 5
5.1 –> 5.2 –> Empty cups? –> 5.3 for each guest
NO

5.1. put milk in cup
5.2. fill cup with tea
5.3. do sugar

New sub-task

Plan 3
3.1 – 3.2 – 3.3

Plan 5.3
5.3.1 – if wanted 5.3.2

3.1. warm pot
3.2. put tea leaves in pot
3.3. pour in boiling water

5.3.1. ask guest about sugar
5.3.2. add sugar to taste

1.1. fill kettle
1.2. put kettle on hob
1.3. turn on and light gas
1.4. wait for kettle to boil
1.5. turn off gas

New sub-task

Plan types in HTA

- Fixed sequence (plan 3 – prepare the teapot)
- Optional tasks (5.3 sugar?)
- Waiting for events (4- wait 4 or 5 minutes)
- Cycles (plan 5 – serve tea)
- Time sharing (1 and 2 prepare teapot, boil water)
- Random (vacuum cleaning rooms)
- Mix of several types

- The result of the analysis depends a lot on the experience of the analyst

- **Different analysts usually produce different results** (mainly at the detail level) varying with the goal of the analyst

Task analysis information sources

- The quality of task analysis results cannot be better than the original data

  "garbage in garbage out"

- The process of analysis in general triggers new questions, thus several phases of data collection and analysis are needed

- There are several types of information sources:

  - Documentation
  - Observation → (expensive)
  - Interviews

Documentation:

- Manuals, instruction books, training documentation ... are very good information sources
- But they describe what people are supposed to do, not what they actually do
- System's manuals usually describe functionality, not how they are used
- Observation and user interviews should be performed based on this information
- Be careful with user interviews!!

Interviews:

- Interviewing domain experts is a good way of getting information about the task; should include:
  - General questions (e.g. a typical day)
  - Specific questions (e.g. why did you do that?)
  - Task decomposition (~ HTA)

Observation:

- It is always necessary to perform (formal or informal) observation to understand the tasks
- Reading documentation and observing users is a good starting point
- More observation should follow:
  - In the lab
  - In the field
  - Passive (only observation)
  - Active (questions, post-task walkthrough)

Using Task Analysis:

- May be used in:

    - Manuals and teaching materials

    - High-level system design

    - Detailed design of the system user interface

- In the first case users are observed while performing tasks using the system

- In the other cases task analysis contributes to the design of the new system

Manuals and teaching materials

- The first task analysis techniques were developed to train people to perform a task

  (e.g.: clean a gun)

- HTA may be used to structure manuals or tutorials

  (e.g: how to prepare tea)

- May be used also to help users transfer from one system to another

Obtaining requirements

- TA is not a direct way of obtaining a system requirements as it refers to an already existing system and not to the new one

- However, it may give a good contribution

- In general the new system includes old and new functionality

- TA may help determine:

    - What objects, tasks, etc., should be maintained

    - What should be included

II- User Models

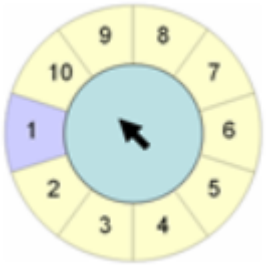
- User models of the users' mental, perceptual and motor processes (GOMS, KLM…)

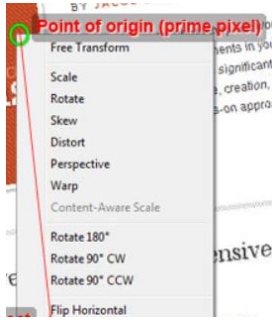
- Personas- fictional characters based upon research in order to represent the different types of users

- …

https://www.interaction-design.org/literature/book/the-encyclopedia-of-human-computer-interaction-2nd-ed/personas

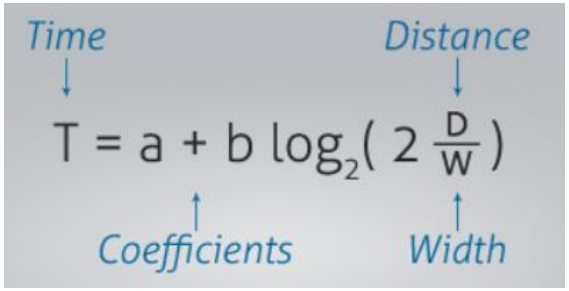
Fitts's law

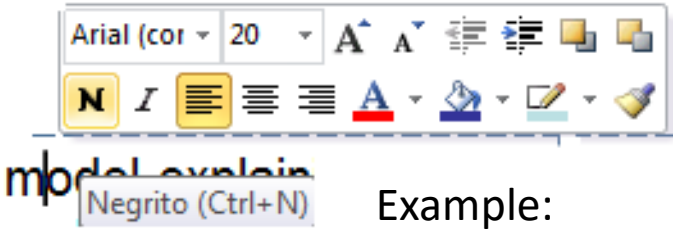




- Empirical model explaining speed-accuracy tradeoff characteristics of human muscle movement with some analogy to Shannon's channel capacity theorem

- Estimates the average time a user takes to select a target considering the distance (D) from the cursor and the Width (W) of the target:



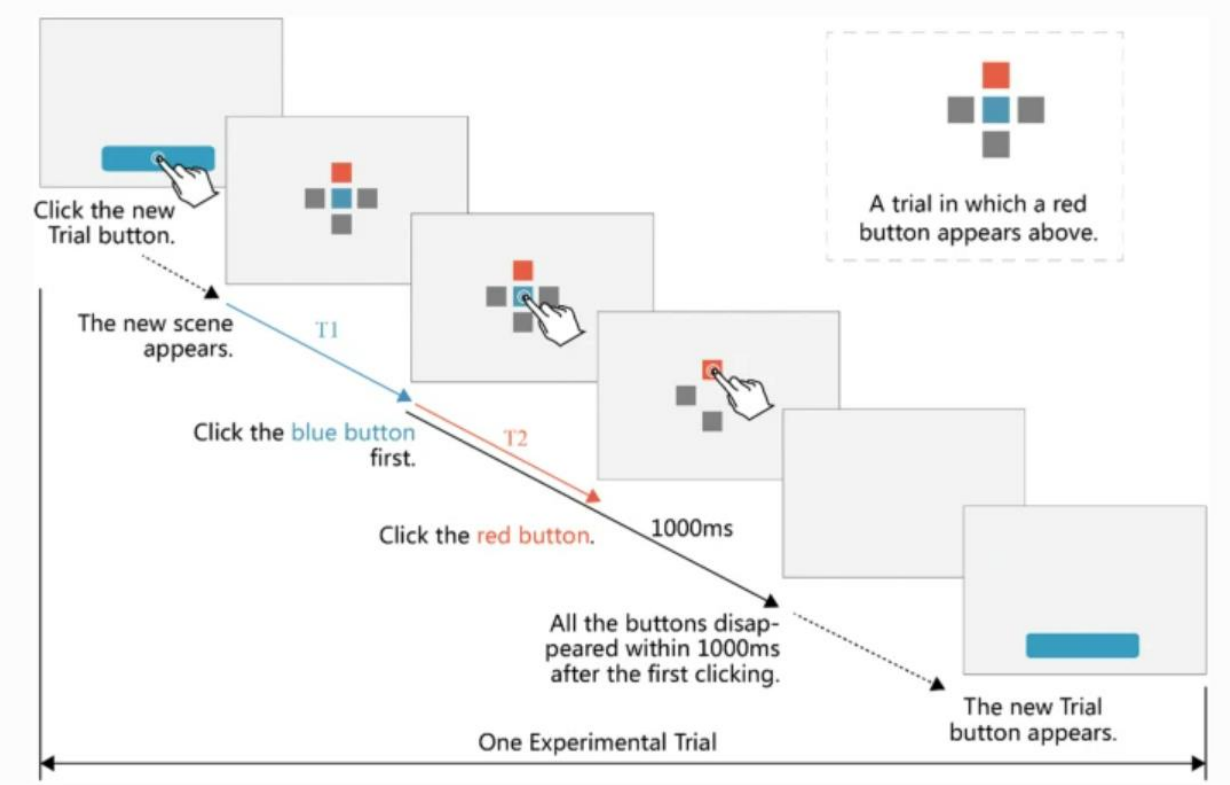


Example:
Minimizing D

- The larger the target the easier to select (no fine control needed)
- The farther the target from the cursor the longer it will take

http://www.interaction-design.org/encyclopedia/fitts_law.html

Example: using Fitts's law in Virtual Environment research



Zhou, X., Guo, Y., Jia, L. *et al.* A study of button size for virtual hand interaction in virtual environments based on clicking performance. *Multimed Tools Appl* **82**, 15903–15918 (2023). https://doi.org/10.1007/s11042-022-14038-w

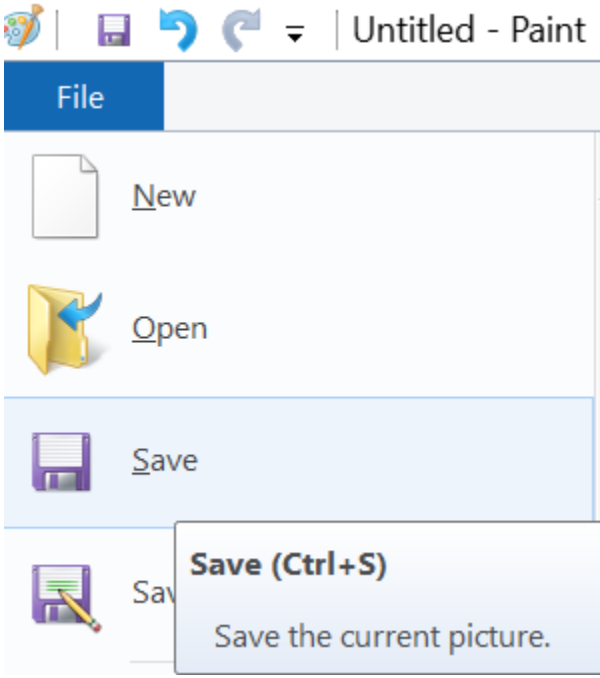
GOMS- Goals, Operators, Methods and Selections

- Proposed by Card, Moran and Newell, 1983
- A GOMS decomposition has the following elements:
- ***Goals***: what the user wants to attain
- ***Operators***: basic operations that the user has to perform to use the system; may affect the system or not (press a key or read a message)
- ***Methods***: possible decompositions of the goal into sub-goals (e.g. Select an option “Save” or press “ctrl S”)
- ***Selections***: rules to select the possible methods (taking into account the type of user and the system status)

https://digital.ahrq.gov/health-it-tools-and-resources/evaluation-resources/workflow-assessment-health-it-toolkit/all-workflow-tools/goms

Example: ‘save’ a file: using two common ways

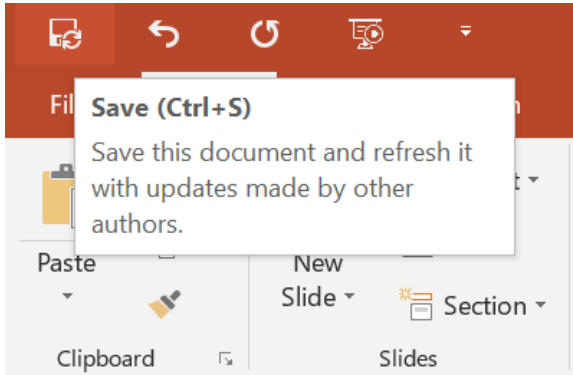
- GOAL: **SAVE-A-DOCUMENT**
  - . [select GOAL: USE-SAVE-OPTION-METHOD
  - . . MOVE-POINTER-TO-MENU-BAR
  - . . CLICK-OVER-FILE-MENU
  - . . MOVE-POINTER-TO-SAVE-ICON
  - . . CLICK-SAVE-ICON
  - . GOAL: USE-CTRLS-METHOD
  - . . PRESS-’CTRL’+’S’-KEYS



User BSS:

Rule 1: **USE-CTRLS-METHOD** unless other rule applies

Rule 2: If has hand on mouse/touch pad **USE-SAVE-OPTION-METHOD**



GOMS- Goals, Operators, Methods and Selections

- A typical GOMS analysis consists in decomposing a high level goal in a sequence sub-goals
- Selection rules must be adjusted to the user profile
- Analyzing the structure of the GOMS decomposition may give an **approximate measure** of :
  - Short Term Memory load (depth of the goal structure)
  - Time needed (a time for each operator)

Example: Copy/scan an article from a journal

- Goal: Photocopy/scan-paper
- . Goal: Locate-article
- Goal: Photocopy/scan-page repeat
- Goal: Orient-page
- open cover
- select-page
- position-paper
- close-cover
- Goal: Press-copy-button
- Goal: Verify-copy (only if copy)
- locate-out-tray
- examine-copy
- Goal: Collect/send-copy
- locate-out-tray
- remove-copy/send pdf (outer goal satisfied)
- Goal: Retrieve-journal
- open-cover
- remove-journal
- close-cover

Closure problem
(the user attains the goal before the task is complete)

The “closure problem”

In earlier ATMs the money was given before returning the card

... many users left the card: their goal was getting money!

This was changed.

The copies usually are available to the user before they remove the original from the photocopier and walk away!

To prevent this, the overall goal should be satisfied only after removing the original

The “closure problem” in MultiBanco

In stores usually these are the following steps:

- Insert the card
- Insert the pin code
- Transaction approval -> audio signal
- Remove the card
- Receipt is handed to the client

At the ATMs the money is given (goal satisfaction) only after the card is removed by the client

These procedures help not to forget the card!

GOMS- Goals, Operators, Methods and Selections

- Capacities:
  - It has been used in cognitive model research
  - It may describe adequately how **experienced users** perform **routine tasks**
  - Associated to a device model allows time estimates

  Limitations:
  - It does not give information concerning user knowledge to estimate training or transfer times
  - It requires experience to apply correctly

Differences between GOMs and Task Analysis (TA)

- The scope of Task Analysis is very wide
- TA models also aspects of the real world not part of the system
  (example: feeding paper into a printer; getting paper documents)
- TA describes the tasks users perform from an external point of view and has more detail
- GOMS aims at understanding the user's cognitive processes while performing the task
- TA is more used in early phases of the S/W lifecycle and GOMS for evaluation

Main bibliography

- Y. Rogers, H. Sharp, J. Preece, *Interaction Design: beyond human-computer interaction*, 5th ed., Willey, 2019

https://learning.oreilly.com/library/view/interaction-design-beyond/9780470665763/

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- Dan Diaper, Neville Stanton, *The Handbook of Task Analysis for Human-Computer Interaction*, CRC Press, 2003

- Ian Sommerville, *Software Engineering*, 10th ed., Pearson, 2016

Interesting links:

- http://www.usabilitybok.org/goms
- http://www.usabilitybok.org/task-analysis
- http://web.mit.edu/6.813/www/sp17/classes/09-more-efficiency/

"Look inside" the following books:

Y. Rogers, H. Sharp, J. Preece, *Interaction Design: beyond human-computer interaction*, 3rd Edition, Willey, 2011,

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https://books.google.pt/books?id=cGm8DgAAQBAJ&printsec=frontcover&source=gbs_ge_summary_r&cad=0#v=onepage&q&f=false

D. Benyon, *Designing Interactive Systems*, 3rd ed., Pearson, 2014

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