Graphical User Interface

- Layout and Design

Responsible persons:

Regula Stopper

(Overall)

René Sieber

(Content)

Samuel Wiesmann

(Revision)

Olaf Schnabel

(Revision)

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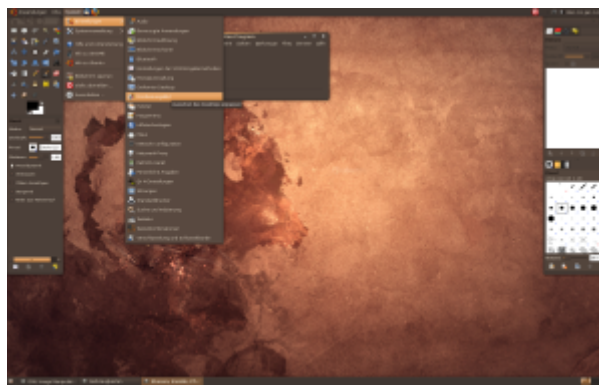# 1. Graphical User Interface - Layout and Design
Learning Objectives

You will be able...

- ...to explain what a Graphical User Interface (GUI) is and what it is good for.
- ...to design a Graphical User Interface for an interactive map.

Introduction

Don't you think that it is easier to click on a button to initialise a computer action than typing specific commands in a command line? Surely, if you are a computer expert you would say that the command line is more comfortable but if you are a beginner you would agree that clicking on buttons is the easier way to handle the computer's actions. That is why Graphical User Interfaces were invented. They ease the handle of computer programs.

GUI (screenshot © Ubuntu)

When designing a Graphical User Interface, it is important that the needs, wants, and limitations of the end users (who finally use the programm) are given extensive attention. There exist a few rules for the design of Graphical User Interfaces which will be listed in this lesson.
Since the topic of this module is multimedia cartography, we will concentrate on Graphical User Interfaces of interactive maps.

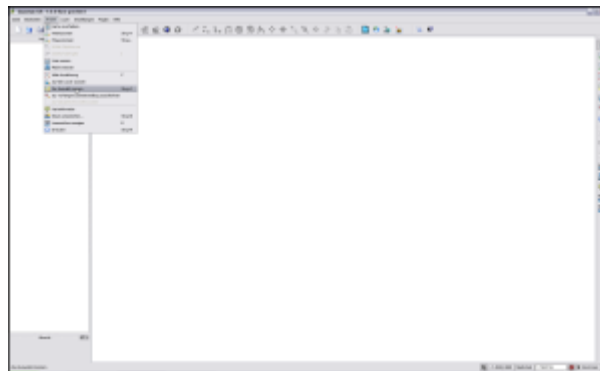# 1.1. User Interface versus Graphical User Interface

Learning Objectives

You will be able...

- ...to explain what a User Interface is.
- ...to describe what a Graphical User Interface (GUI) is and list at least three features of a today's GUI.

Introduction

If you click on an arbitrary button (pdf, glossary or help button, etc.) or interactive item (interactive index, link, etc.) while reading this lesson, you interact with the computer system.

When you sit in front of the screen of a running computer, you always face a User Interface (UI). As the name implies, a User Interface is an interface between the user and the computer. The first user interfaces were command-line interfaces where you only could interact with the computer by typing commands on the keyboard (some Unix users still use this kind of interface). Today, we (Mac, Linux and Windows-Users) expect to interact with the computer using a mouse, launching programs by clicking on icons, and manipulate various windows on the screen using graphical controls. Such user interfaces are called Graphical User Interfaces (GUI), since they use graphics and pictures to represent the input and output of a program.


GUI (screenshot © Quantum GIS)

1.1.1. Interacting with a System

Before talking about User Interfaces and Graphical User Interfaces, we want to begin with the basics. How machines and humans interact.

First we want to describe the stages of actions users go through when faced with the task of using a system. According to (1988) there are seven stages of a typical user interaction with a generic interaction system:

1. Forming the goal: I want to do something in a program.
2. Forming the intention: I have to start the program.
3. Specifying the action: I have to click on a button to open the program.
4. Executing the action: I click on the button.
5. Perceive the system state: Note that the computer operates.
6. Interpret the system state: The computer opens (hopefully) the right program.
7. Semantically evaluating the interaction outcome: Note that the right program is open.
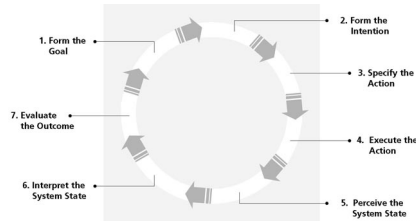
Product Designing according to (Marinilli 2002)

First, the user forms a conceptual intention from her/his goal. Second, s/he tries to adapt this intention to the commands provided by the system and from these commands carries out the action. Then, the user attempts to understand the outcomes of her/his actions. This is particularly important for computer systems, where the inner workings are hidden and users have to figure out the internal state only from few hints. The last three stages help the user to develop her/his idea of the system. The whole process is performed in a cycle of actions and evaluation. The user refines the model of the system s/he has in mind by interpreting the outcome of her/his actions. (Marinilli 2002)

1.1.2. Types of User Interfaces

To work with a system, the users need to be able to control the system and assess the state of the system.
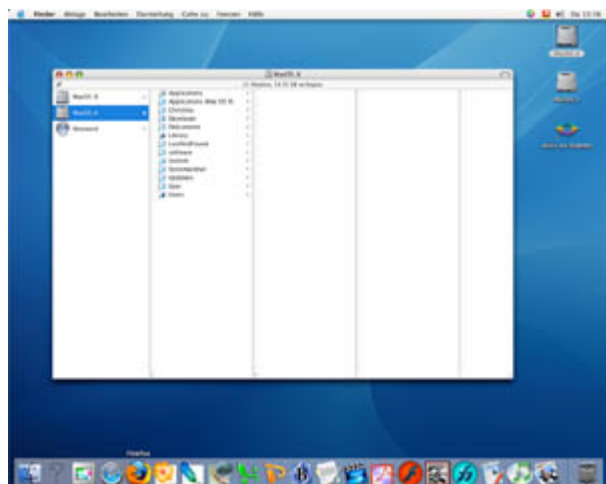
Definition of User Interface

In computer science and human-computer interaction, the user interface (of a computer program) refers to the graphical, textual and auditory information the program presents to the user. The user employs several control sequences (such as keystrokes with the computer keyboard, movements of the computer mouse, or selections with the touchscreen) to control the program. (Wikipedia)

There exist several types of user interfaces. We here give you just two examples:

- **Command-Line Interface (CLI)**: The user provides the input by typing a command string with the computer keyboard and the system provides output by printing text on the computer monitor (Wikipedia).
- **Graphical User Interface (GUI)**: The use of pictures rather than just words to represent the input and output of a program (Linuxjunkies). Input is accepted via devices such as keyboard and mouse.

Command-Line Interface

Graphical User Interface (screenshot © Apple)

Graphical User Interfaces will be discussed in detail in the following chapters.

1.1.3. Graphical User Interface

Definition of Graphical User Interface (GUI)

> Graphical User Interfaces use pictures and graphics instead of just words to represent the input and output of a program. The program displays certain icons, buttons, dialogue boxes etc. on the screen and the user controls the program mainly by moving a pointer on the screen (typically controlled by a mouse) and selecting certain objects by pressing buttons, etc. (Linuxjunkies)

Short History of GUI

"Today, almost everybody in the developed world interacts with personal computers in some form or another. We use them at home and at work, for entertainment, information, and as tools to leverage our knowledge and intelligence. It is pretty much assumed whenever anyone sits down to use a personal computer that it will operate with a graphical user interface. We expect to interact with it primarily using a mouse, launch programs by clicking on icons, and manipulate various windows on the screen using graphical controls. But this was not always the case." (Reimer 2005)

until 1970	Command Line Interfaces: Text-based user interfaces requiring commands to be typed on the keyboard.

from 1973	GUI-Prototypes: Development of the first operational "Alto" Computer at the Xerox Palo Alto Research Center (PARC). The Alto is the first system to pull together all of the elements of the modern Graphical User Interface. (toastytech.com)

Features:

- 3-button mouse
- Bit-mapped display
- Use of graphical windows

(toastytech.com)

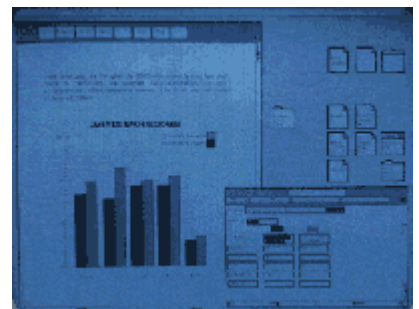|	
1981	Xerox introduces the "Star", the commercial successor to the Alto. (toastytech.com)

Notable Features:

- Double-clickable icons
- Overlapping windows
- Dialog Boxes
- 1024*768 monochrome display

(toastytech.com)

1983	Apple introduces the new computer "Lisa". (toastytech.com) Notable Features:	

- Pull down menus
- Menu Bars
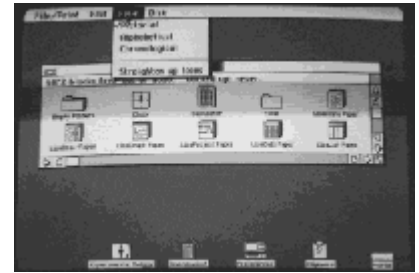
(toastytech.com)

	Visi Corp releases Visi On, the first integrated graphical software environment for IBM PCs. (toastytech.com)	
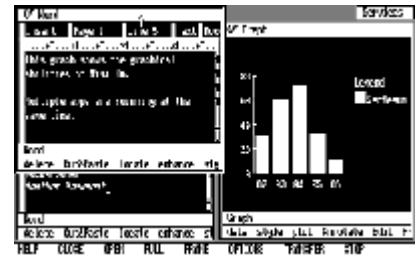
(toastytech.com)

1984	Apple introduces the Macintosh. (toastytech.com)	
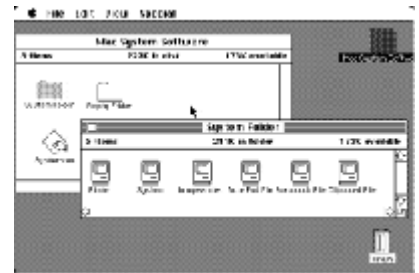
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Today	Graphical User Interfaces are very common and are used for almost all programs.	
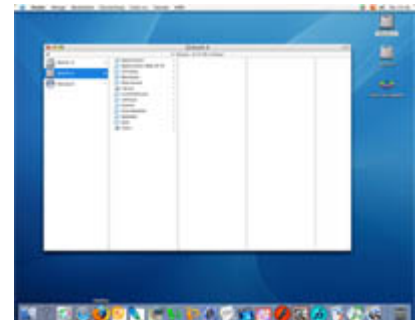
(screenshot © Apple)

1.1.4. Unit-Summary

Humans interact with computers. There are seven stages of actions users go through when faced with the task of using a system:

1. Forming the goal
2. Forming the intention
3. Specifying the action
4. Executing the action
5. Perceive the system state
6. Interpret the system state

7. Semantically evaluating the interaction outcome

User Interface

In computer science and human-computer interaction, the user interface (of a computer program) refers to the graphical, textual and auditory information the program presents to the user, and the control sequences (such as keystrokes with the computer keyboard, movements of the computer mouse, and selections with the touchscreen) the user employs to control the program. (Wikipedia)

Graphical User Interface

"Graphical User Interface is the use of pictures rather than just words to represent the input and output of a program. A program with a GUI runs under some windowing system (e.g. The X Window System, Microsoft Windows, Mac OS). The program displays certain icons, buttons, dialogue boxes etc. in its windows on the screen and the user controls it mainly by moving a pointer on the screen (typically controlled by a mouse) and selecting certain objects by pressing buttons on the mouse while the pointer is pointing at them. " (Linuxjunkies)

1.2. Graphical User Interface Design

## Learning Objectives

You will be able...

- ...to name the main principle of User-Centered-Design.
- ...to list at least four of the "Golden GUI Design Rules".
- ...to list the four GUI control groups.
- ...to list the four ways to catch the user's attention.

Introduction

Designing a user interface may seem a simple and side aspect of the development of an entire application. In fact it is, perhaps, the most important part of the development of an application.

Marinilli says: "*Designing professional user interfaces is not only a matter of a good graphic artist and some good ideas. Unfortunately, people creating user interfaces just go for a product, without even being aware of the basics or the theoretical principles behind it.*" (Marinilli 2002)

When designing a user interface you always have to be aware that you create a product that is used by other people. Often, designers are too busy to create an award-winning, cool product without being aware that the product may be a complete mystery and unusable for the end users.
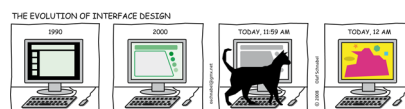
A user intreface must be user-friendly (Schnabel 2008)

This unit will deal with some of the theory behind quality user interfaces, especially graphical user interfaces. We will show you what GUI controls exist and how you can get the user's attention on the screen.

1.2.1. Visual Communication

The three basic principles of visual communication according to (1992) are:

- **Organisation**: Give the user a simple, clear, and consistent conceptual structure.
- **Economy**: Maximise the effectiveness of a minimal set of tools.
- **Communication**: Adjust your presentation to the intake capacity of your users.

Designing a non-economic user Interface (Schnabel 2008)

1.2.2. User Interface Design

Design in General

"*Design is inherently creative and unpredictable.* " (Shneiderman et al. 2005)

(1985) characterize design as following: Design is a process; it is not a state and it cannot be adequately represented statically. The design process is non-hierarchical; it is neither strictly bottom-up nor strictly top-down.

These characterisations of design convey the dynamic nature of the process.

GUI Design

An end user will never be able to read the designer's mind. What might seem an easy application for the designer team might be awkward and difficult to employ by the end user. (Marinilli 2002)

"*When planning a UI, a designer should focus on the needs of the end users. It often happens, instead, that designers are too busy with citations from other cool, award-winning products that may result in a nightmarish implementation for the developer and a complete mystery for the end user.* " (Marinilli 2002)
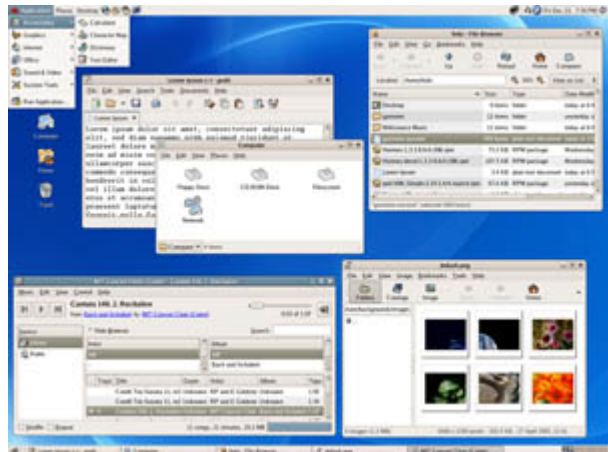

Product Designing (Schnabel 2008)

Desktop Metaphor

The function of a Graphical User Interface is to facilitate the handling of an application by means of graphical elements. The design of today's graphical user interfaces often uses the so called "desktop metaphor".

"*The desktop metaphor [1] is a set of unifying concepts currently used in a number of graphical user interfaces in computer operating systems. The monitor of a computer represents the user's desktop upon which documents and folders of documents can be placed. A document can be opened into a window, which represents a paper copy of the document placed on the desktop.*" (Wikipedia)

Virtual Desktop (Desktop Metaphor) (Wikipedia)

Real Desktop (Wikipedia)

The desktop metaphor itself has been extended and stretched with various implementations. Today, we find trash cans on the desktop as well as disks and filing cabinets.

1.2.3. User-Centered Design

What is User-Centered Design?

The process from the idea of a project until its realisation and usage, often ends up as following:

---

[1] *A metaphor is a figure of speech that implies comparison between two unlike entities, as distinguished from simile, an explicit comparison signalled by the words "like" or "as". The metaphor makes a qualitative leap from a reasonable, perhaps prosaic comparison, to an identification or fusion of two objects, to make one new entity partaking of the characteristics of both.*
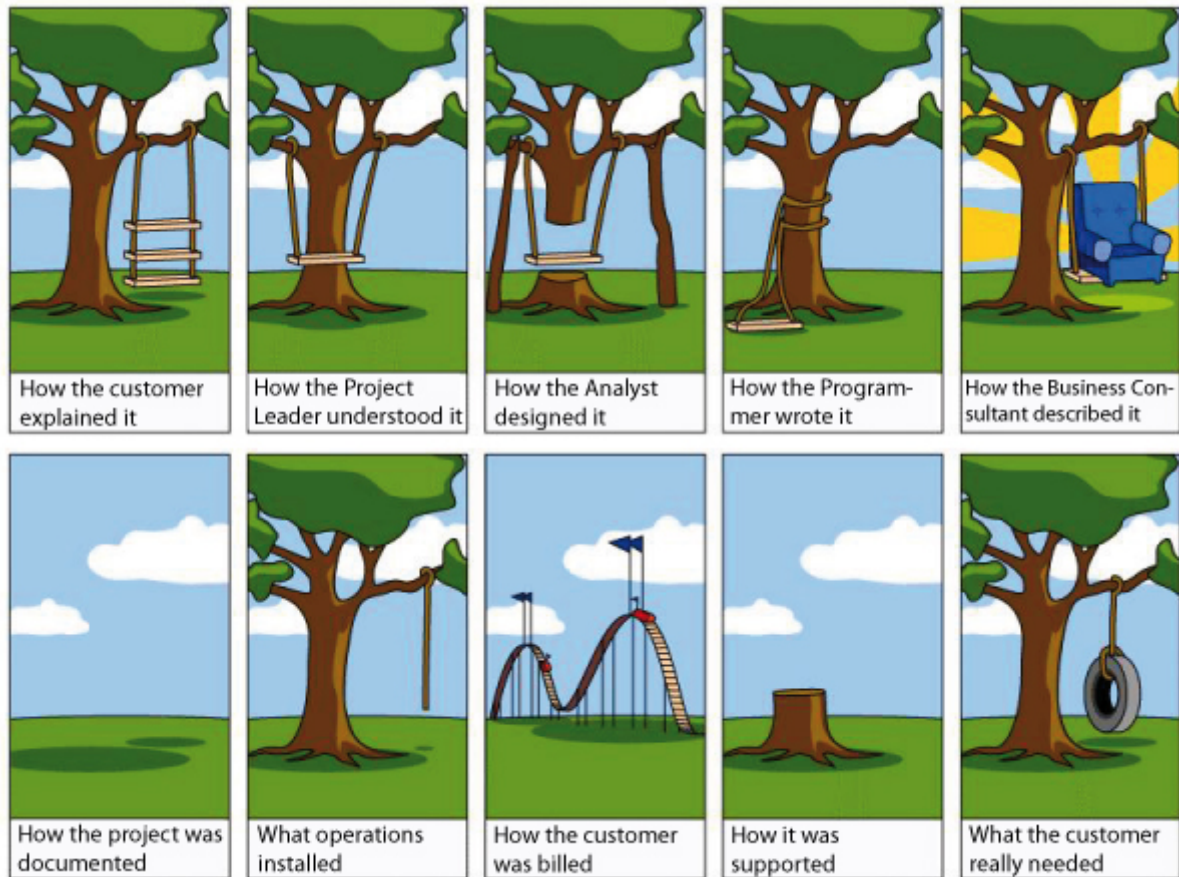
As User Interface Design should not end up (enabled.com)

User Centered-Design helps to avoid that processes end up as it is shown in the image above.

"*User Centered-Design (UCD) is a design philosophy and a process in which the needs, wants, and limitations of the end user of an interface or document are given extensive attention at each stage of the design process. User-centered design can be characterized as a multi-stage problem solving process that not only requires designers to analyze and foresee how users are likely to use an interface, but to test the validity of their assumptions with regards to user behaviour in real world tests with actual users. Such testing is necessary as it is often very difficult for the designers of an interface to understand intuitively what a first-time user of their design experiences, and what each user's learning curve may look like.*" (Wikipedia)

User Centered Design concerns itself with:

- **Usefulness**

  Usefulness relates to relevance: do the functions, information, etc. match what the user actually needs? (Katz-Haas 1998)

- **Usability**

  Usability relates to ease-of-use - a simple concept, but not always easy or intuitive to implement. (Katz-Haas 1998)

- **Visual Design**

  Refers to layout recommendations and to the use of graphical elements.

1.2.4. General Design Principles

According to (2005) there are eight principles, called "Golden Rules", that are applicable in most interactive systems.

- **Strive for consistency**. Inconsistencies force people to spend extra time trying to figure out how to find the answers to questions they have. This rule is the most frequently violated one, but following it can be tricky because there are many forms of consistency. Consistent sequences of actions should be required in similar situations; identical terminology should be used in prompts, menus, and help screens; and consistent colour, layout capitalisation, fonts, and so on should be employed throughout. Exceptions, such as required confirmation of the delete command or no echoing of passwords, should be comprehensible and limited in number.

  The following examples show an inconsistent and a consistent thematic navigation.
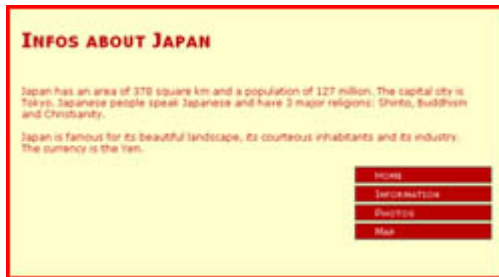
Inconsistent Navigation

Consistent Navigation

- **Cater to universal usability**. Recognise the needs of diverse users and design for plasticity, facilitating transformation of content. Novice-expert differences, age ranges, disabilities, and technology diversity each enrich the spectrum of requirements that guides design. Adding features for novices, such as explanations, and features for experts, such as shortcuts and faster pacing, can enrich the interface design and improve preceived system quality.
- **Offer informative feedback**. For every user action, there should be system feedback. For frequent and minor actions, the response can be modest, whereas for infrequent and major actions, the response should be more substantial. Visual presentation of the objects of interest provides a convenient environment for showing changes explicitly.

  The following examples show two applications which (do not) provide feedback for a minor action, namely clicking on a text.

Which two feedbacks are implemented in the top right example?

- Text Highlighting
- Hand symbol

- **Design dialogs to yield closure**. Sequences of actions should be organised into groups with a beginning, middle, and end. Informative feedback at the completion of a group of actions gives operators the satisfaction of accomplishment, a sense of relief, the signal to drop contingency plans from their minds, and a signal to prepare for the next group of actions. For example, e-commerce web sites move users from selecting products to the checkout, ending with a clear confirmation page that completes the transaction.
- **Prevent errors**. As much as possible, design the system such that users cannot make serious errors; for example, gray out menu items that are not appropriate and do not allow alphabetic characters in numeric entry fields. If a user makes an error, the interface should detect the error and offer simple, constructive, and specific instructions for recovery. For example, users should not have to retype an entire name-address form if they enter an invalid zip code, but rather should be guided to repair only the faulty part. Erroneous actions should leave the system state unchanged, or the interface should give instructions about restoring the state.
- **Permit easy reversal of actions**. As much as possible, actions should be reversible. This feature relieves anxiety, since the user knows that errors can be undone, thus encouraging exploration of unfamiliar options. The units of reversibility may be a single action, a data-entry task, or a complete group of actions, such as entry of a name and address block.
- **Support internal locus of control**. Experienced operators stronlgy desire the sense that they are in charge of the interface and that the interface responds to their actions. Surprising interface actions, tedious sequences of data entries, inability to obtain or difficulty in obtaining necessary information, and inability to produce the action desired all build anxiety and dissatisfaction.
- **Reduce short-term memory load**. The limitation of human information processing in short-term memory (the rule of thumb is that humans can remember "seven plus or minus two chunks" of information) requires that displays be kept simple, multiple-page displays be consolidated, window-motion frequency be reduced, and sufficient training time be allotted for codes, and sequences of actions. Where appropriate, online access to command-syntax forms, abbreviations, codes, and other information should be provided.

Additionally, there is one basic principle which counts for all User Interface designers:
Keep your message as simple as possible. Use only the amount of text and graphics as is absolutely necessary to get your point across! (Skaalid 1999)

1.2.5. GUI Controls

A graphical user interface basically consists of windows and containers (Boxes/Panels/Panes). Within these elements, there are various GUI Control tools. There exist four groups of GUI Controls:

- Input Elements (input field, slider, spin button, etc.)

Type in a text (up to 25 characters)

- Output Elements (output field, status bar, etc.)

Move mouse over this text   Status Bar:

- Selection Elements (radio button, checkbox, combobox, listbox, etc.)

Select Bandwidth   Select a Rose

- Action Elements (toggle button, etc.)

Design of GUI Controls

Many GUI Controls are buttons. A button is a widget which is clickable and which provides the user a simple way to trigger an event, such as selecting the zoom function of an interactive map (Wikipedia). Buttons are always decorated with button graphics (icons), which are placed inside the buttons. These icons identify the action, setting mode, or other function represented by the button.
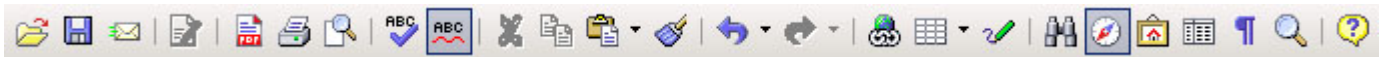
Buttons in the Open Office application (OpenOffice.org 2006)

There are a few design guidelines for the designing of the button icons and the buttons themselves (Sun Developer Network (SDN)):

- Design icons to identify clearly the action represented by the button.
- Keep the drawing style of the icons symbolic; too much detail can make it more difficult for users to understand what the icon represents and thus what a button does.
- Clearly show the action, state, or mode that the button initiates. For example, use a 3D border to indicate that a button is clickable as it is shown in the example below.

Buttons with 3D border (Neumann 2006)

Sometimes, the button graphics are combined with text. This text helps to understand the action of the button, because the button graphics do not always identify the action of a button clearly.

Button Icons combined with text (Atlas of Canada)

Instead of using text in a button, you can use tool tips as well.

Button with Tooltip

1.2.6. Techniques for Getting the User's Attention

Some techniques for getting user's attention are widely employed in user interfaces. They are derived from empirical studies and can be summarized as follows: (Marinilli 2003)

- **Animation**
  Items blinking on the screen easily capture the user's attention. This technique can be disturbing and invasive. Animation is often used to express the GUI internal state, signaling work in progress or activity in general.

- **Colour**
  Like animation, this technique should be used wisely. Too many colours tend to produce confusing GUIs.


Too many colours on the screen

Wisely used colours on the screen
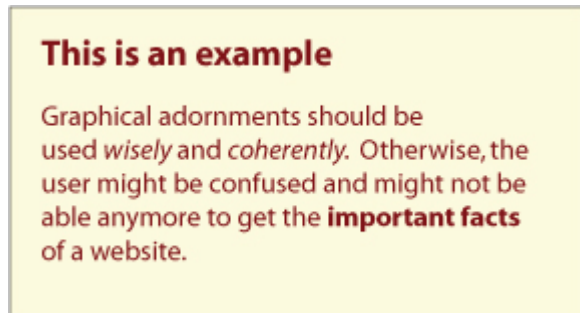
- **Sound**
  As with technique, when used wisely, can be very effective. Indeed, when dealing with disabled people, sound signals could offer an effective feedback means.

- **Graphic Adornments** (such as bold fonts, special graphics, and so forth)
  When used wisely and coherently, these graphic conventions could be effective without being disruptive.
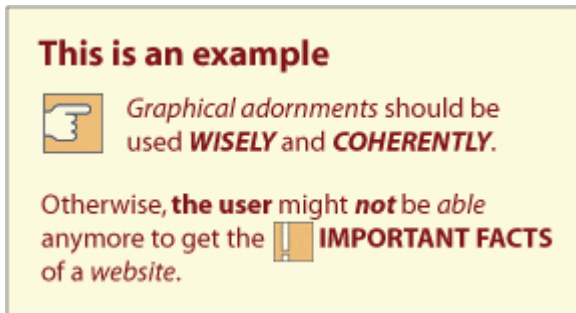
Graphical adornments are not wisely used	*Wisely used graphical adornments*

A few words of caution are necessary. (2005) says: " *There is a danger in creating cluttered displays by overusing these techniques. Some web designers use blinking advertisements or animated icons to attract attention, but users almost universally disapprove. Animation is appreciated primarily when it provides meaningful information [...]. Audio tones, like the clicks in keyboards or ringing sounds in telephones, can provide informative feedback about progress. Alarms for emergency conditions do alert users rapidly, but a mechanism to suppress alarms must be provided.*" (Shneiderman et al. 2005)

1.2.7. Unit-Summary

GUI Design

In this unit, we saw that UI design can be organized around some basic criteria such as striving for consistency to eliminate possible distractions in the UI, providing feedback to the user, avoiding errors or making them easy to handle, and so on. There are different mental models of the same application, those that design it (UI designers), those that implement it (developers) and those that will use it (the end-users). It is important for designers to be aware of the different mental representations involved in the creation and consequent use of a user interface.

The design of a User Interface should always give extensive attention at the needs, wants, and limitations of the end users of an interface. This design philosophy is called User Centered-Design (UCD).

GUI Controls

GUI control tools are tools that allow the user to interact with the system. There exist four groups of GUI Controls:

- Input Elements
- Output Elements
- Selection Elements
- Action Elements

A Graphical User Interface normally contains a lot of action elements that are realised with buttons. Since buttons are mainly decorated with button graphics we listed you a few design rules for these graphics.

- The icon must identify clearly the action of the button.
- The drawing style should be kept symbolic.
- The action, state, or mode that a button initiates should be clearly shown.

User's Attention

There are several techniques to get the user's attention:

- Animation

- Colours
- Sound
- Graphic Adornments

All these techniques should be used wisely. Otherwise they can be disturbing and confusing.

1.3. Layout

Learning Objectives

You will be able to...

- ...to differ the two screen layout strategies.
- ...to list the seven colour contrasts according to Itten (1970).

Introduction

You certainly once looked at an application layout and thought "What an awful layout!". Perhaps, it was only the unsuitable combination of different colours. But it may also be the bad chosen layout strategy for an application.

In this chapter, we introduce you two layout strategies which can be applied to applications. We do not want to give you any advice which layout must be chosen in wich case. We rather show you the possibilities to arrange layout elements on the screen. The decision which layout strategy you want to apply depends on the application, the end users, the content, etc.

Colours play an important role within the topic of layout. Especially the combination of colours must be well chosen. Therefore, we introduce you seven colour contrasts and show you how they effect your eyes and therefore your impression. Neither in this chapter, we give you advices about which contrasts to use and which not. Depending on the effect you want achieve you have to choose the corresponding colour contrast.

*Dense Screen Layout* (Weskamp)

1.3.1. Screen Layout

According to (2003) there are mainly two strategies to manage the layout of the display area:

- **High-Density Layout Strategy** (for conveying a high volume of information)

  - *Tabular Arrangement*: Data is organized in a list of structured values.

Tabular Arrangement (Weskamp)

- *Hierarchical Organisation*: The information is structured into tree-like hierarchy as in a file system graphic representation.
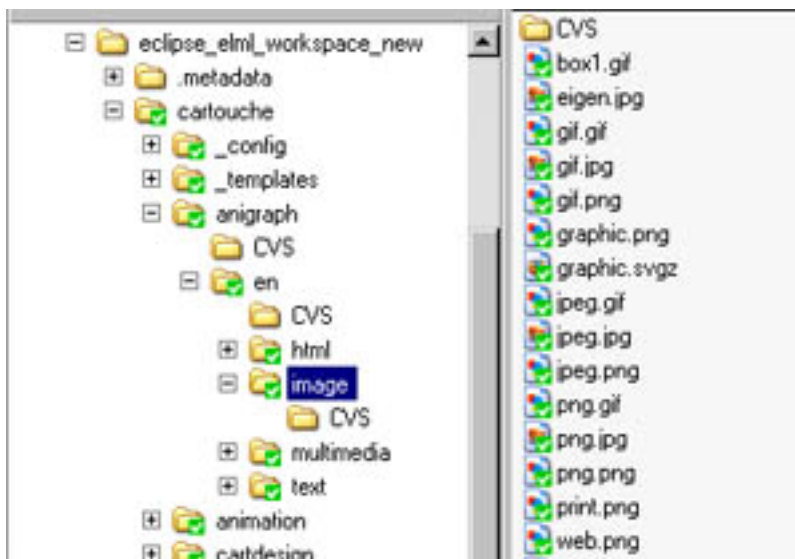
Hierarchical Organisation

- *Graph*: Data is represented graphically, like a chart or a diagram.

Graph (Inxight)

- **Limited Information Layout Strategy** (where the aim is to reduce the displayed data)

    - *Step-By-Step Interaction*: The data are cut up and displayed in one-page stages (e.g. Wizard Interface).
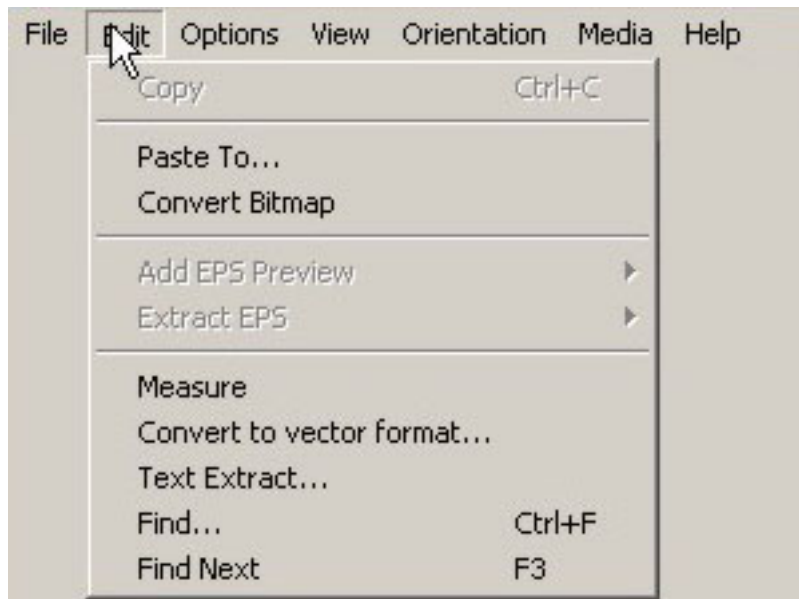

Wizard Interface with Back and Next buttons (screenshot © Eclipse)

    - *Details on Demand*: Some optional data can be shown on user request (e.g. dialogs that have a "more details" button).
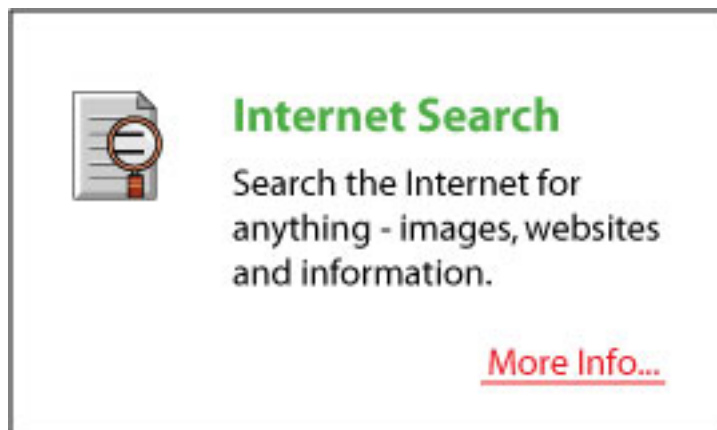
Optional data can be shown on user request

    - *Disable/Minimise Irrelevant Information*: There are many ways to minimise data; e.g. shading it.

Disabled Unavailable Information for a Menu (screenshot © Ghostgum Software)

These strategies are complementary and should always be used toghether in every GUI screen. Depending on the case, one of the two will be dominant, but it is essential to be accurate in the exact mixing of them. (Marinilli 2003)

1.3.2. Colour Contrast

We will not talk about colours in general, because there is enough literature on the Internet that deals with colour theory. We only want to introduce the seven colour contrasts as described by (1970), because colour contrast is an important aspect when designing a GUI.

- **Pure Colour Contrast**: Pure Colour Contrast results from the juxtaposition of saturated colours that are clearly different. This contrast is peak when the three primary colours are juxtaposed to one another. (The Voice of Color)


Pure Colour Contrast according to (Itten 1970)

- **Light-Dark Contrast**: A light colour next to a dark colour has a stronger effect than next to an equally light or lighter colour. The effect of hues can be intensified by greater differences in brightness. (ERCO Light Scout)

Light-Dark Contrast

- **Simultaneous Contrast**: This contrast demonstrates contrast by displaying how a colour looks different when placed next to other colours (Rudner). Colours change their effect due to the influence of the surrounding colours (ERCO Light Scout).
  The round dots are all exactly the same shade of gray. Clearly, the lightness of the background effects the way in which we perceive the center gray dot.
  The gray annulus appears greenish on the red background and on the green background reddish.
  The orange annulus looks brighter on the pink background than on the green background.
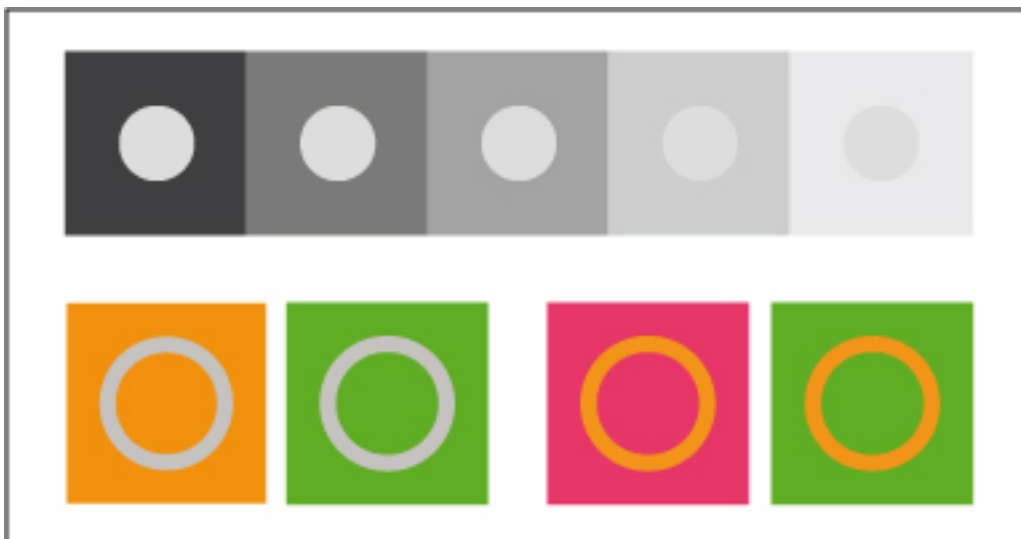

Simultaneous Contrast

- **Complementary Contrast**: The pairs of colours lying opposite in the colour wheel. Yellow-violet displays the largest light-dark contrast, orange-blue the largest cold-warm contrast. (ERCO Light Scout)
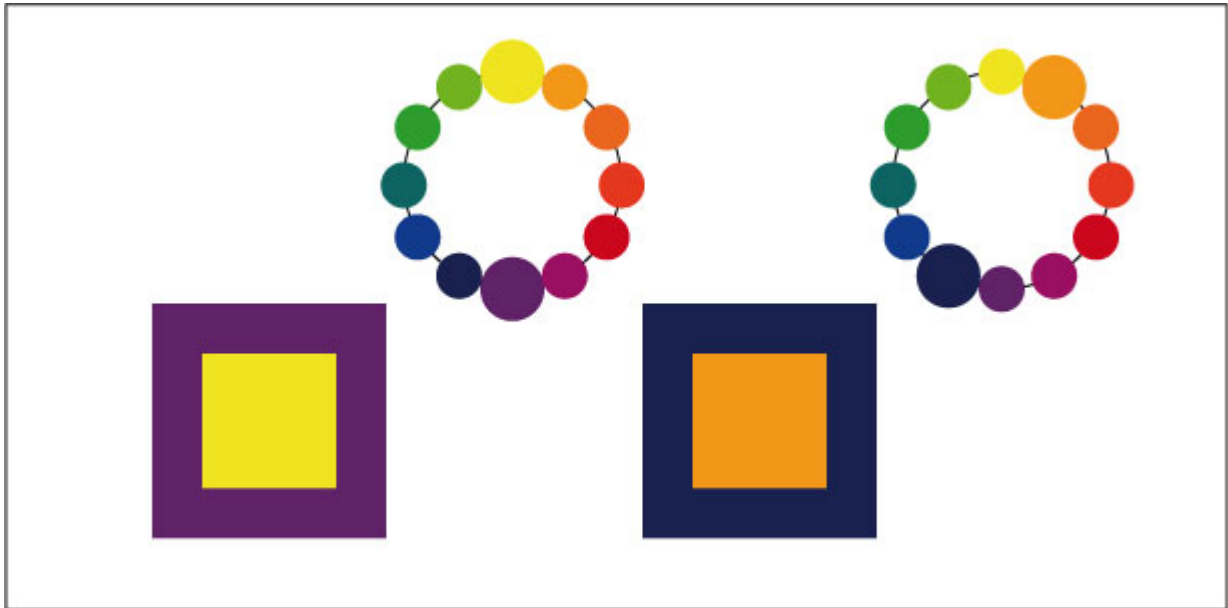
Yellow-Violet and Blue-Orange Contrast

- **Warm-Cold Contrast**: In the colour wheel, the warm colours with red and yellow components are located opposite to the cold blue hues. Green and magenta form the neutral transitions. The effect of a predominant colour can be increased when combined with an accent from the opposite colour (ERCO Light Scout). This combination makes warm hues appear warmer, and vice versa.
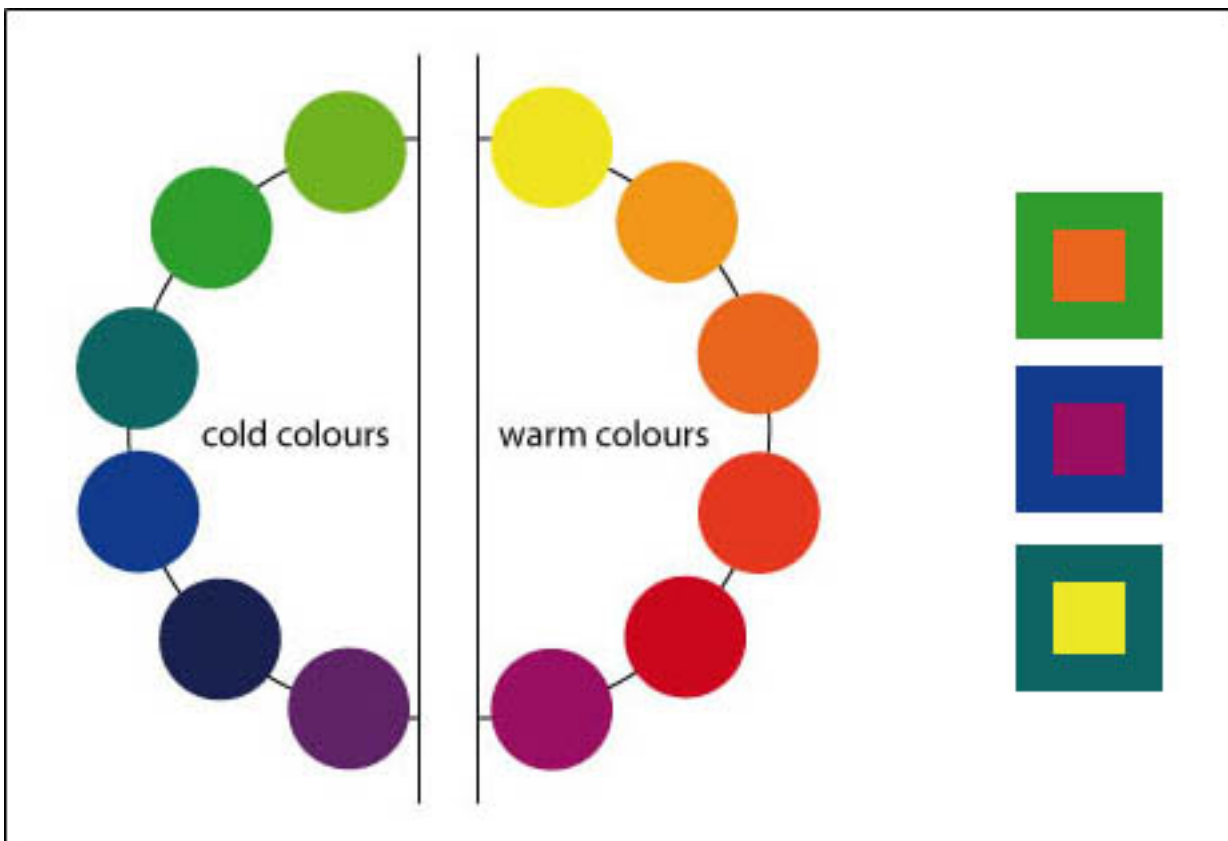
*Warm-Cold Contrast according to* (Itten 1970)

- **Quality Contrast** (or Intensity Contrast): The quality contrast describes the distinction between pure colours and murky colours. Mixing pure colours with grey shades makes the former murky and dull, and the quality of colour purity is lost. Pure colours have a dominating effect over murky colours. (ERCO Light Scout)
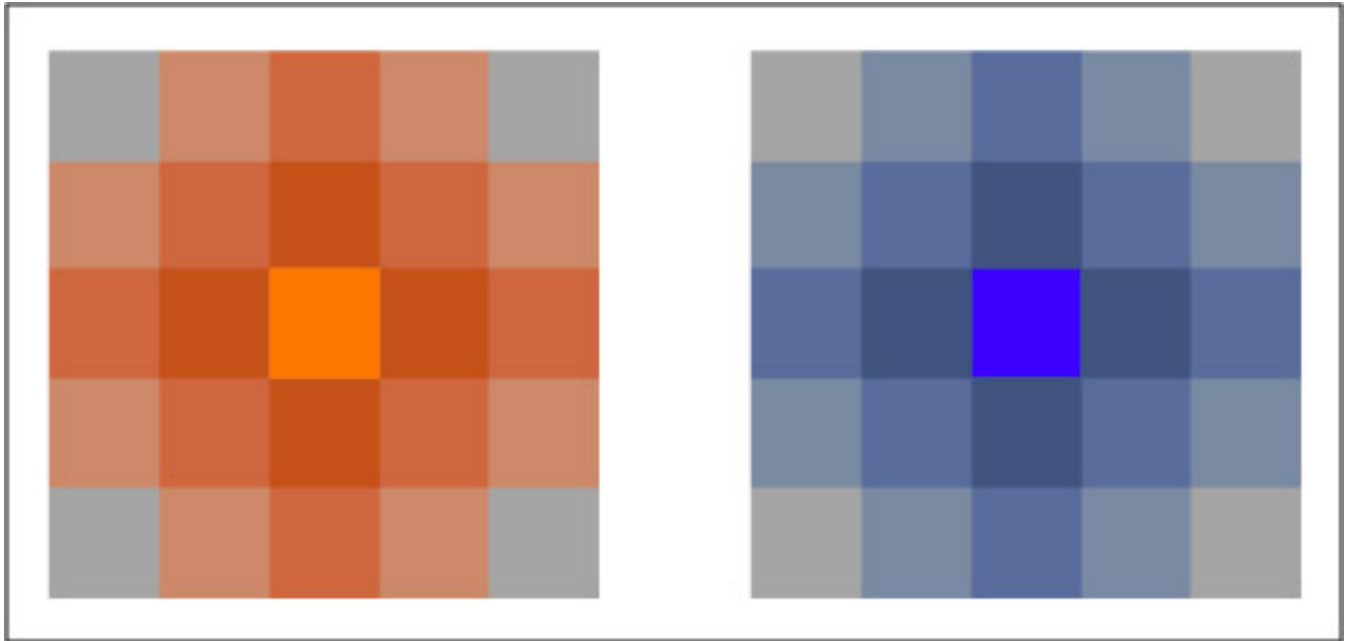
Quality Contrast according to (Itten 1970)

- **Quantity Contrast**: The quantity contrast referes to the relationship of the size of one coloured area with the next. A large coloured area with a small area in a contrast colour increases the chromatic effect of the main colour. (ERCO Light Scout)
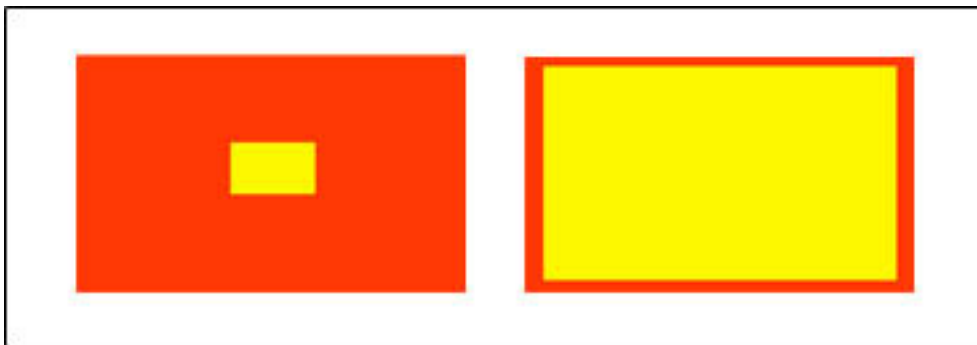
Quantity Contrast

Special attention has to be paid on colour-blind people. People with colour deficiencies may have difficulty distinguishing certain colours (e.g. red/green; about 8% of men and 1% of women affected). There exist a few web pages where you can check your images for colorblind compatibility. Sometimes, they give advises on how to produce images which are compatible for colourblind people. An exemplary website is the one of **vischeck.com**.

1.3.3. Unit-Summary

Screen Layout

There exist two main strategies (which are further subdivided) to manage the layout of the display area:

- **High-Density Layout Strategy**

- Tabular Arrangement
- Hierarchical Organisation
- Graph
- **Limited Information Layout Strategy**
  - Step-By-Step Interaction
  - Details on Demand
  - Disable/Minimise Irrelevant Information

These strategies are complementary and should always be used toghether in every GUI screen. Depending on the case, one of the two will be dominant, but it is essential to be accurate in the exact mixing of them. (Marinilli 2003)

Colour Contrast

According to (1970) there exist seven colour contrasts:

- Pure Colour Contrast
- Light-Dark Contrast
- Simultaneous Contrast
- Complementary Contrast
- Warm-Cold Contrast
- Quality Contrast
- Quantity Contrast

When designing a GUI these contrasts play an important role. A designer has to aware of the effects of the combination of different colours.

1.4. GUI for Interactive Maps

Learning Objectives

You will be able...

- ...to name at least three functional groups with their subgroups.
- ...to assign any function of any interactive map to their corresponding functional group or sub-group.
- ...to list the four rules for item organisation on the screen.

Introduction

Since the main topic of this module is multimedia cartography, we here concentrate on the GUI of interactive maps. We already talked about User Interface and Graphical User Interface in general. We now want to introduce tools or items that are typical for interactive maps.

Each tool of an interactive map can be assigned to a functional group. This means that tools with similar functions can be classified into groups. For example zoom in, zoom out, and pan can be pooled within the functional group "Navigational Functions". Precisely, we talk about spatial navigation what is a sub-group of navigational functions in general. You now see that we distinguish between the main functional groups and further divide them into sub-groups.

Spatial Navigation in Atlas of Switzerland 2 (Atlas of Switzerland 2004)

Considering the classification of the tools, the tools must be arranged on the screen. There exist a few content organisation rules that we present you in this chapter. Further on, we picked a few interactive maps and analysed them according to our tool classification and their arrangement on the screen. We do not give you advices how to arrange an interactive map best. Depending on the features, the end users, the message of the map, etc. you have to define your own content organisation. The presented examples show you a few possible content arrangements of an interactive map.

1.4.1. Functional Groups

(2006) specifies the following functional groups (based on the theories of (1993), (1997) and (2005)), that we find in interactive maps (You do not have to memorise all these functions we just want to give you an overview of the existing functions. The most frequently ones are marked with a bold font):

Functional Groups	Functional Sub-Groups	Functions
General Functions		Mode Selection, **Language Selection**, File-Import/Export, **Print**, Setting Bookmarks, **Map History (Forward / Backward)**, Settings (Preferences), Display of System State, **Tooltip**, HotSpot, Help, Imprint, Home, Exit
Navigational Functions	Spatial Navigation	**Enlarge/Reduce Map** (Zoom In/Zoom Out, Magnifier), **Move Map** (Pan, Scroll), **Reference Map/Globe**, Map Rotation, **Determination of Location** (Altitude/Coordinates), Line of Sight and Angle, Setting Pin, Spatial/Geographical Index, Spatial/ Geographical Search, Tracking
	Thematic Navigation	**Theme Selection, Theme Change**, Theme Index, Theme Search, Theme Favourites
	Temporal Navigation	**Time Selection** (Positioning on Time Line, Selection of Time Period/Time), Animation (Start/Stop)
Didactical Functions	Explanatory Functions	Guided Tours (Round Trip/Routes), Preview, **Explanatory Texts, Graphics, Images, Sound, Films**
	Self-Control Functions	**Quizzes, Games**
Cartographic and Visualisation Functions	Map Manipulation	**Switch on and off Layers, Switch on and off Legend Categories**, Manipulation of Symbolisation, Changing of Projection
	Redlining	**Adding Own Map Elements**, Adding Labels
	Explorative Data Analysis	**Modification of Classification**, Modification of Appearance/State (Brightness, Position of the Sun), Map Comparison, Data Selection
GIS-Functions	Space- and Object-Oriented Query Functions	**Spatial Query/Position Query** (Coordinates Query/Query of Altitude), **Distance and Area Measuring, Creating Profile**
	Thematic Query Functions	**Thematic Queries** (Data-/Attribute Queries), **Access to Statistical Table Data**
	Analysis Functions	Creation of Zones, **Intersection, Aggregation and Overlapping** (Transparent Overlapping / Fading), **Terrain Analysis** (Exposition, Slope, etc.)

Table of Functional Groups according to (Cron 2006)

You will never find all the listed functions in one and the same interactive map. Interactive Atlases feature the most functions. In the next chapter, we explain the various functions and show you a few screenshots of some functions for each functional group or subgroup.

Exercise

You want to produce an interactive map that visualises the population density of Switzerland. Which of the functions listed above would you integrate in the interactive map? Consider the User Centered-Design where the requirements of the end user are very important.

Put a list of your chosen functions and one reason for each function why to implement it, on the Discussion Board "Functional Groups". Look at the entries of your colleagues. If you do not agree with an entry of your colleagues discuss it on the discussion board.

1.4.2. Functional Group Examples

General Functions

General functions are found not only in interactive maps, but also in other media. Language selection, importing, exporting and printing files as well as help and exit functions are the most common ones.
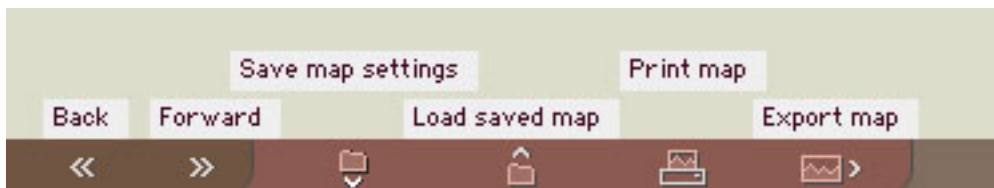
General Functions in Atlas of Switzerland 2 (Atlas of Switzerland 2004)

Navigational Functions

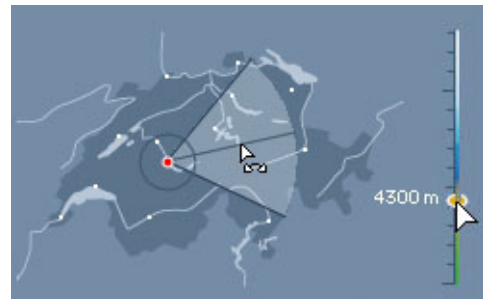There are three types of navigational functions: spatial, thematic, and temporal navigation.

Spatial Navigation   The functions for spatial navigation allow to define the position in the map via zoom, pan or by means of a reference map / globus.

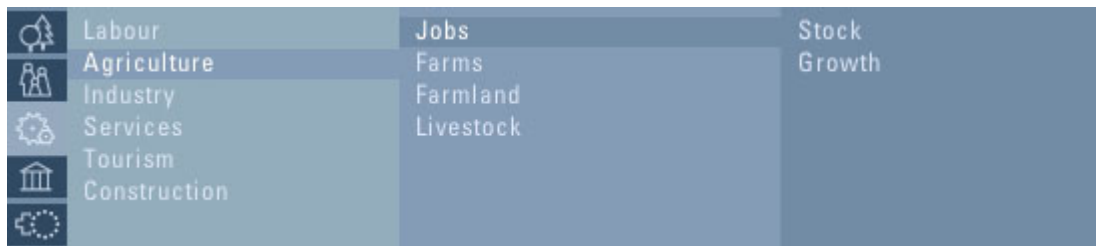*Spatial Navigation in Atlas of Switzerland 2* (Atlas of Switzerland 2004)

Panorama Lift and Determination Angle (Atlas of Switzerland 2004)

Thematic Navigation   Thematic navigation functions define the orientation in the thematical structure of an interactive map. They allow the selection of a theme and the changeover to another theme.

Part of the thematic navigation in Atlas of Switzerland 2 (Atlas of Switzerland 2004)

Temporal Navigation

Temporal navigation functions facilitate the temporal positioning by means of a time line or other time control elements.

Temporal Navigation (Isakowski 2003)

Didactical Functions

The integration of didactical elements in interactive maps expand the information content of a map. Such elements clarify and structure the information of an interactive map. Didactical functions consist of the two sub-groups explanatory functions and self-control functions.

Explanatory Functions

These functions provide explanatory texts, images, sound, films, pre-defined thematic routes (guided tours), simple models, and animations.

Explanatory Functions in Atlas of Switzerland 2 (Atlas of Switzerland 2004)

Self-Control Functions

A user is able to control his/her acquired knowledge with these functions. Self-Assessments in form of games or quizzes deal with the presented subject and provide food for thoughts. Automatic feedback informs the user about the correctness of his/her answers.
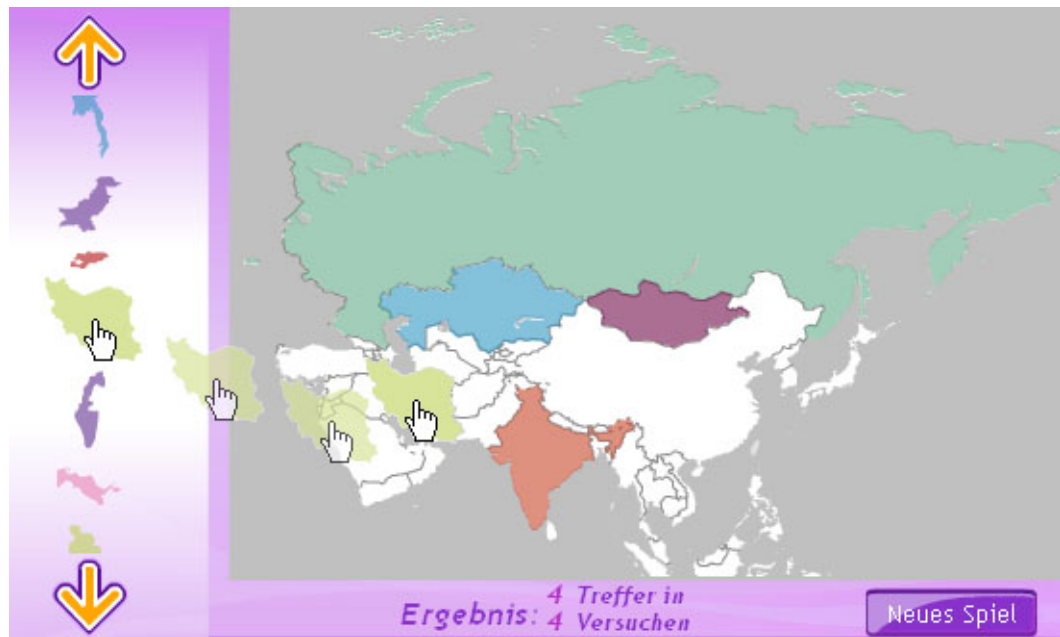
Game of the Encarta Atlas (Microsoft Encarta 2006)

Cartographic and Visualisation Functions

Cartographic functions allow the graphical modification of the map on the screen. Each user can modify the visualisation of the map to his taste. Besides map manipulation, redlining and explorative data analysis are part of this functional group.

Map Manipulation   The user is able to change the presentation of the screen map to his taste. For interactive maps, the most important function of this sub-group is switching on and off layers or changing of the symbolisation (e.g. colour).
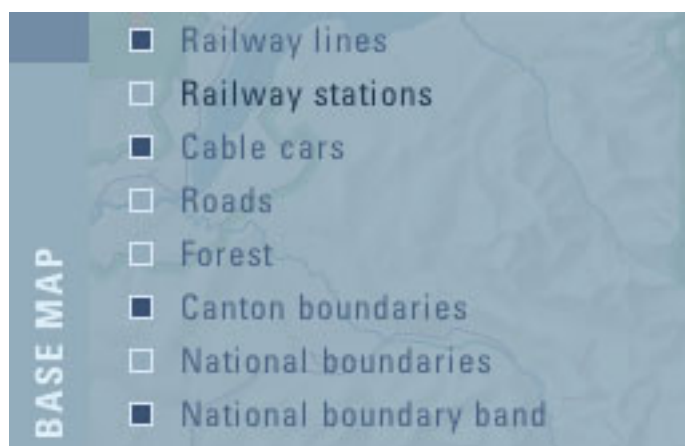
Switch on and off Layers in Atlas of Switzerland 2 (Atlas of Switzerland 2004)

Redlining   Redlining allows to add map elements such as labels, comments/notes, marks, or geometric elements to the existing screen maps. In doing so, the original map is not modified.
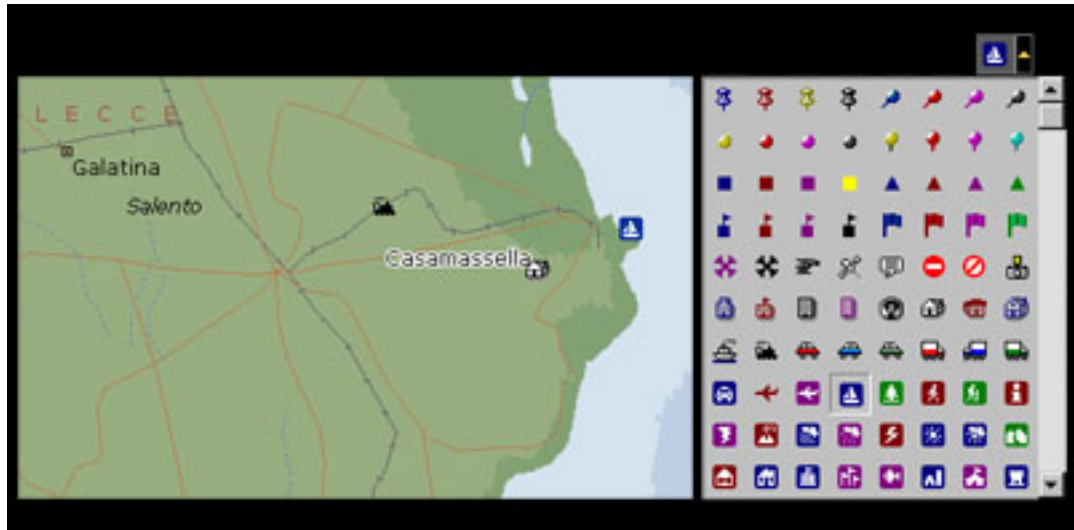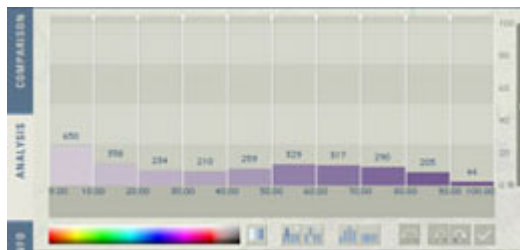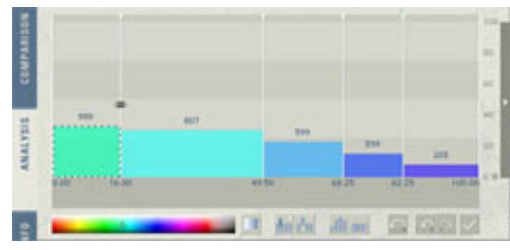
Adding Map Elements in Encarta Atlas (Microsoft Encarta 2006)

Explorative Data Analysis

These functions allow to detect spatial correlations by means of data visualisation in maps, diagrams or graphics. An example is the classification modification of statistical data.

Original Data Classification in Atlas of Switzerland 2 (Atlas of Switzerland 2004)

Modified Data Classification in Atlas of Switzerland 2 (Atlas of Switzerland 2004)

GIS Functions

GIS functions handle both graphical data and data that is stored in a database. Often, the query you send is handled in the database and the result is graphically visualised in the map. You are able as well to make only queries that are handled on the graphical side of the system. Therefore, this functional group consists of spatial and thematic query functions and of general analysis functions.

Space- and Object-Oriented Query Functions

Spatial-Oriented queries provide the position (in coordinates and altitude) of the cursor. Therefore, they can be seen as a part of the spatial orientation. The measuring of distances and areas can be processed by means of the map's geocoding.

Creating Profile (Neumann 2002)

Thematic Query Functions

With thematic queries, attributes (thematic data) of an identified object can be enquired.

Access to Statistical Table Data (Neumann 2002)

Analysis Functions

GIS analysis functions visualise the correlations between spatial phenomenons. They combine relational database data with spatial interpretation and output the result (often) in form of maps. The resulting map visualises the data relationships. The main functions are overlapping, creation of zones, and aggregation. The terrain is often analysed for example the exposition, slope, etc.
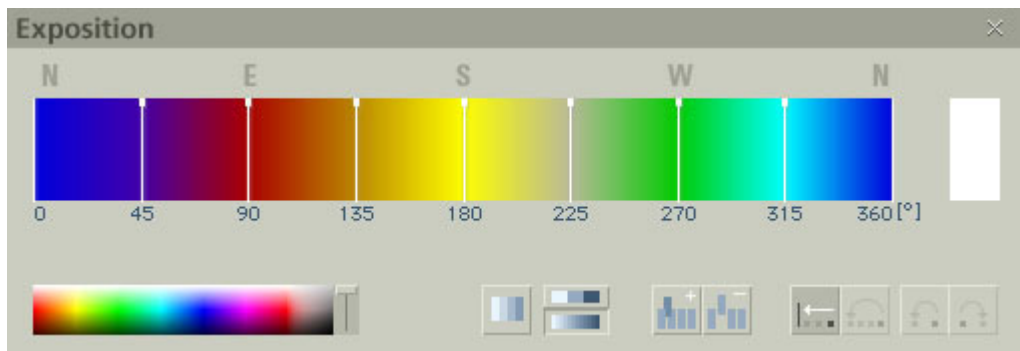
Setting Exposition options in Atlas of Switzerland 2 (Atlas of Switzerland 2004)

1.4.3. Content Organisation

" *Meaningful grouping and sequencing of menu items, along with careful editing of titles and labels and appropriate layout design, can lead to easier-to-learn menus and increased selection speed.*" (Shneiderman et al. 2005, p. 286)

Task-Related Grouping

Grouping objects with similar functions together in one spot can make a page feel more consistent.

Since computer-menu problems include overlapping categories, extraneous items, conflicting classifications in the same menu, unfamiliar jargon, and generic terms, grouping menu items is sometimes difficult (Shneiderman et al. 2005). (2005, p. 286-287) suggests several rules for menu item organisation:

- *Create groups of logically similar items.*



GUI is divided into functional groups
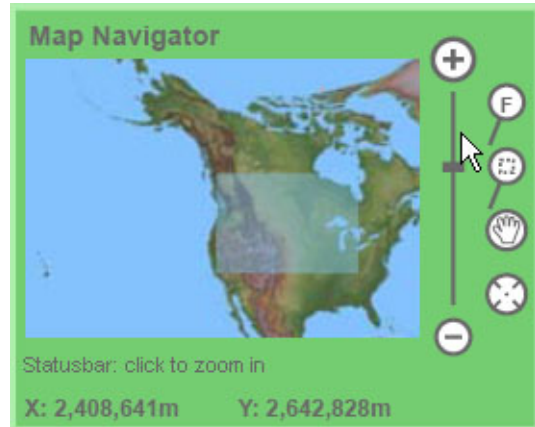
For example the navigation elements build one group

- *Form groups that cover all possibilities*: For example, a menu with age ranges 0-9, 10-19, 20-29, and >30 makes it easy for the user to select an item.

Time Line contains all values from the time before Christ until today.

- *Make sure that items are non-overlapping.* An example for overlapping categories is "Entertainment" and "Events"; one for non-overlapping categories is "Concerts" and "Sports"
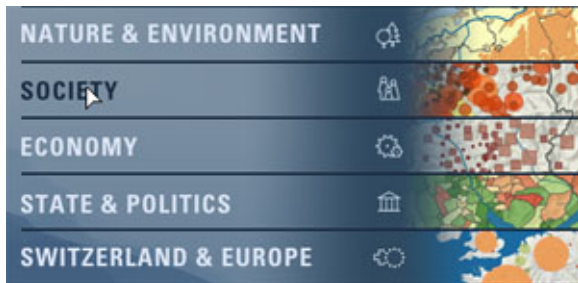
Themes that are not overlapping (Atlas of Switzerland 2004)

Items that are not overlapping

- *Use familiar terminology, but ensure that items are distinct from one another.* Generic terms such as "Day" and "Night" may be too vague; more specific options such as "6.00-18.00" and "18.00-6.00" may be more useful and precise.
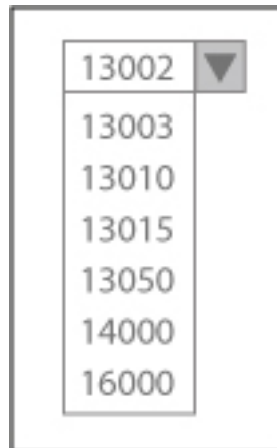
Item Presentation Sequence

Once the items in a menu have been chosen, the designer is still confronted with the choice of presentation sequence. If the items have a natural sequence - such as days of the week, chapters in a book - then the decision is trivial. Typical bases for sequencing items according to (2005, p. 286-287) are:

- *Time* (chronological ordering)
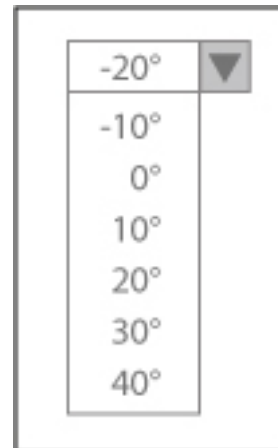- *Numeric Order* (ascending or descending ordering)

- *Physical properties* (increasing or decreasing lenght, area, temperature and so on)

Order acoording to temporal properties　　*Numeric Order*　　*Order acoording to physical properties*

Many cases have no task-related ordering and the designer must choose from such possibilities as these (Shneiderman et al. 2005, p. 286-287):
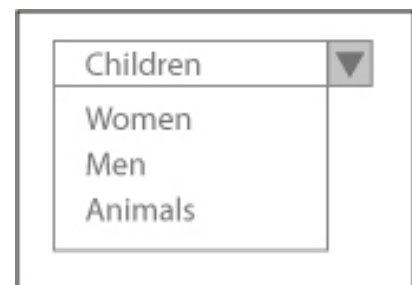
- *Alphabetic sequence terms*
- *Grouping of related items*
- *Most frequently used items first*
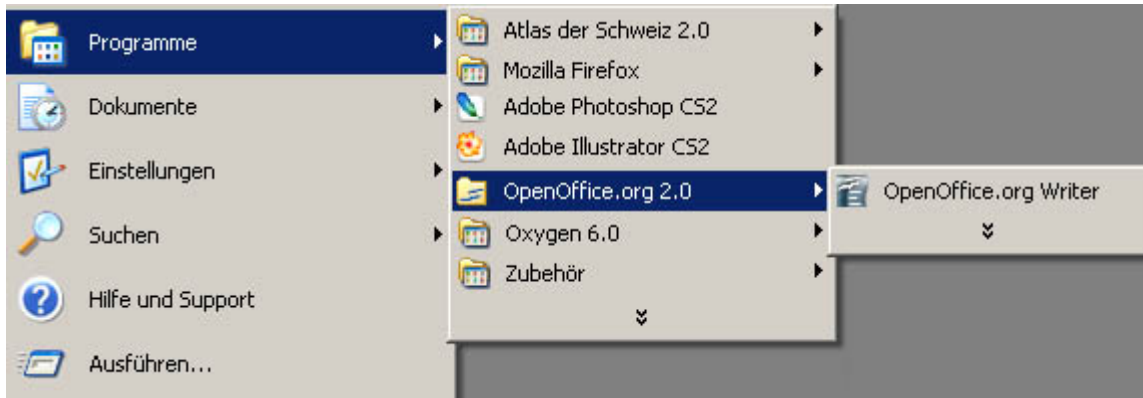- *Most important items first*

Alphabetic Order

Grouping of related items

Most important items first

Most frequently items first

We presented you all examples with selection lists. Needless to say, that the sequence which is chosen for the item presentation applies not only to selection lists but also to all other cases where the ordering of items is necessary.

1.4.4. GUI Examples

We here present you a few GUI examples for interactive screen maps. We explain shortly the possibilities of the applications and highlight the segmentation of the GUIs. You will see that there are several possibilities to arrange the GUI elements of an interactive map. We here want to show you that there is no one and only solution for the arrangement of a GUI of an interactive map. Depending on the content and the functionalities of a map, the arrangement varies significantely.

Georeferenced Photos of Switzerland

This is an application that visualises photos with a spatial reference. The location where the photos are taken is shown in the map as well as the orientation of the camera. You can look at the photos by clicking on the red points in the map. You are even able to search geographically or thematically for photos: You can select one or more thematic keywords to start the thematic search or you can select one or more administrative units to start the geographic search. The resulting photos are shown in a "Photo Selection Window". When selecting a photo in this window you can zoom directly to this photo or see the photo in higher resolution.

Application Georeferenced Photos of Switzerland (MEYER 2006)   *Functional Groups in the application*

Link to the application: **Georeferenced Photos**

Modeling the Dynamics of Migration in Urban Areas

This application visualises the residential segregation in urban regions (here in Zurich). Not only geographical but also social distances are of great importance. To calculate the social distance of a relocation movement a "social-geographical space" is used. Appropriate this social-geographical space has two dimensions of differentiation: status and lifestyle. This social landscape serves to analyze social changes like the individualisation of lifestyles and changes in segregation patterns like gentrification or downgrading neighbourhoods. (Sotomo)

Within this application, you can select various themes, change the classification of the data, change the colour of the choropleths, etc.
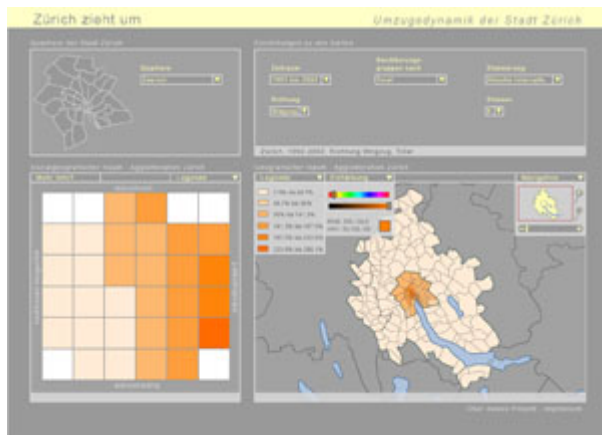
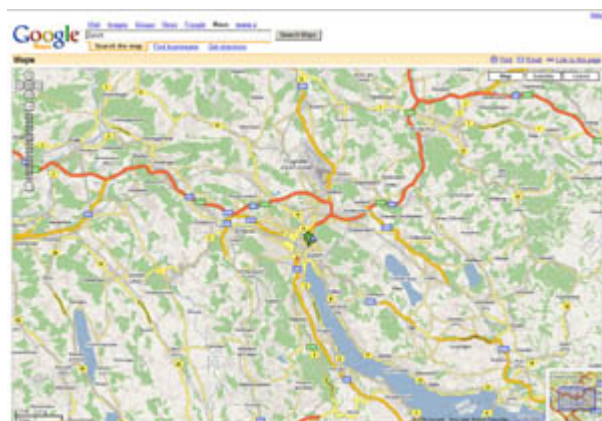*Application Dynamics of Migration* (Isakowski 2003)
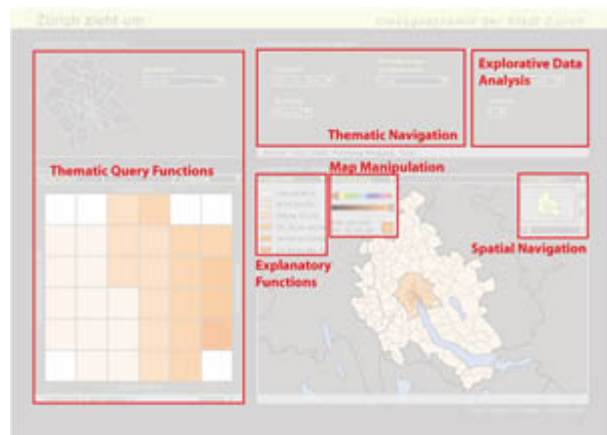
Functional Groups in the application

Link to the application: **Dynamics of Migration**

Google Maps

Google Maps is a map search engine. You can search for an arbitrary location or route. The address(es) of the location or route must be typed in an input bar. The map then directly zoomes to this location. You can zoom and pan in the map and adjust the map's appearing by toggling three map layers.

Application Google Maps (Google Maps)
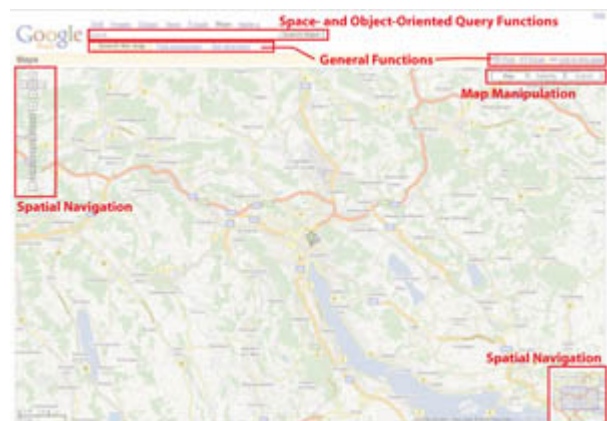
Functional Groups in the application

Link to the application: **Google Maps**

Map24

Map24 as well as Google maps is a map search engine. But Map24 features more tools than Google Maps. Besides navigating in the map, you have the possibility to measure distances, to highlight map features, to zoom out for quick orientation, etc. You even have the possibility to get a 3D-view of the map extent.

Application Map24 (Map24)

Functional Groups in the application

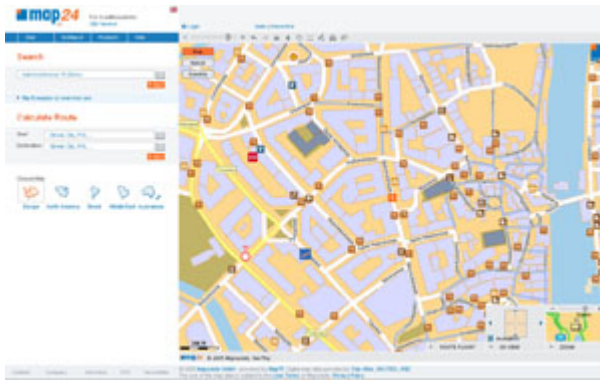Link to the application: **Map24**

Atlas of Switzerland 2.0

The Atlas of Switzerland is not a web application. It is a commercial product that runs from DVD. This application is the most complex one of the ones we presented you in this lesson. It features a huge amount of tools. We only can mention the most important ones here: theme selection, navigation functions, analysis functions, possibility to compare values of the map, setting pins, loading maps, saving maps, map history, etc.
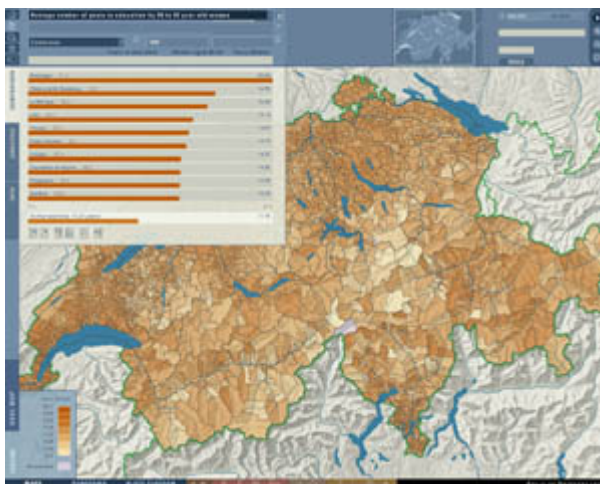
Application Atlas of Switzerland 2.0 (Atlas of Switzerland 2004)
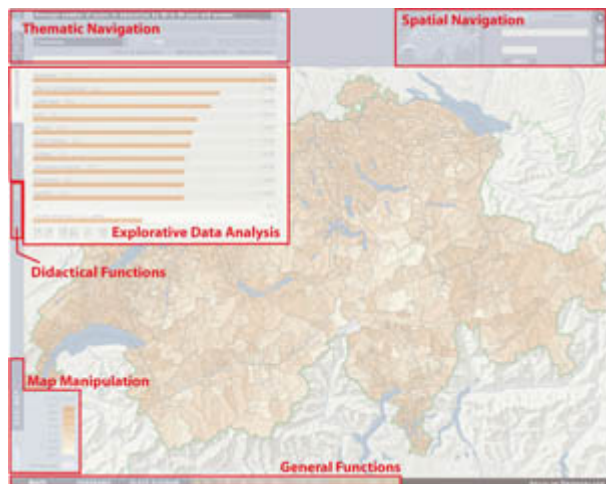
Functional Groups in the application

1.4.5. Unit-Summary

Each control element in a GUI of an interactive map can be classified into several functional groups. Some of these functional groups are further sub-divided into functional sub-groups:

- **General Functions**
- **Navigational Functions**
  - Spatial Navigation
  - Thematic Navigation
  - Temporal Navigation
- **Didactical Functions**
  - Explanatory Functions
  - Self-Control Functions

- **Cartographic and Visualisation Functions**
    - Map Manipulation
    - Redlining
    - Explorative Data Analysis
- **GIS-Functions**
    - Space- and Object-Oriented Query Functions
    - Thematic Query Functions
    - Analysis Functions

A good content organisation of a GUI leads to an easier-to-learn or easier-to-handle application. An important part of the content organisation is the grouping of objects with similar functions. There are a few rules for the item organisation of a GUI:

- Create groups of logically similar items.
- Use familiar terminology, but ensure that items are distinct from one another.
- Make sure that items are non-overlapping.

There is no one and only solution how to arrange best the elements of a GUI of an interactive map. We therefore showed you several GUI examples of interactive maps. Depending on the tools, the use, and the target audience of the interactive map, the content arrangement varies significantely.

1.5. Self Assessment

Multiple Choice Test

Click the right answers in the self assessement below. The "Show Solutions" button allows to compare your answers with the solutions. You can do the test again by clicking on the "Reset All" button.

Exercise

There is a cookbook of the steps that are necessary for the design of a GUI of an interactive map:

1. Definition of functional groups
2. Definition of GUI elements (general and map specific)
3. Grouping of GUI-elements and structuring of screen layout
4. Definition of colour concept
5. Graphical design of GUI-elements

Build groups of four students and make an appointment for a meeting (each group separately). Inform your tutor about the date, location and time you want to meet (at the end of the meeting the tutor will have a look at the solutions).

Each group has to figure out a topic that is to be visualised in an interactive map. Each group will develop a GUI by going through the steps of the presented cookbook. For each step, you have to discuss and define the wanted items (functional groups that will be implemented, how the GUI will be arranged, and so on). Write down your results for each step and show them to the tutor at the end of the meeting. He will discuss your results with you.

You will see that it is not easy to find a solution for a GUI because each member of the group has his/her preferences and opinion. Nevertheless, try to find a solution on which all members of the group agree.

1.6. Summary

User Interfaces are interfaces between the user and the computer. Via the interface the user controls the computer's actions.

Graphical User Interfaces (GUI) are a sub group of User Interfaces. These interfaces use pictures rather than words to represent the input and output of a program. "*The program displays certain icons, buttons, dialogue boxes etc. in its windows on the screen and the user controls it mainly by moving a pointer on the screen (typically controlled by a mouse) and selecting certain objects by pressing buttons on the mouse while the pointer is pointing at them.*" (Linuxjunkies)

UI design can be organized around some basic criteria such as striving for consistency to eliminate possible distractions in the UI, providing feedback to the user, avoiding errors or making them easy to handle, and so on.

The design of a GUI should be User-Centered. That means that the needs, wants, and limitations of the end user of an interface are given extensive attention at each stage of the design process.

A GUI exists of four groups of GUI controls:

- Input Elements
- Output Elements
- Selection Elements
- Action Elements

GUI for Interactive Maps

A GUI of an interactive map consists of several map control elements that can be classified in the following functional groups and sub groups:

- **General Functions**
- **Navigational Functions**
  - Spatial Navigation
  - Thematic Navigation
  - Temporal Navigation
- **Didactical Functions**
  - Explanatory Functions
  - Self-Control Functions
- **Cartographic and Visualisation Functions**
  - Map Manipulation
  - Redlining
  - Explorative Data Analysis
- **GIS-Functions**
  - Space- and Object-Oriented Query Functions
  - Thematic Query Functions
  - Analysis Functions

A good content organisation should always be strived for. Therefore, the grouping of objects with similar functions is an important part of the content organisation. Here are a few rules for the item organisation of a GUI:

- Create groups of logically similar items.
- Use familiar terminology, but ensure that items are distinct from one another.
- Make sure that items are nonoverlapping.

The design of a GUI is always stamped with the designers ideas and mental attitude. Often, we cannot say that one GUI is better than another because each user acts different and has his/her own preferences in the handling of an application. Especially the choice of colours and their combination is a matter of taste. Therefore, one may like the appearing of a GUI and an other person does not like the Interface at all.

1.7. Glossary

Command-Line Interface (CLI):

The user provides the input by typing a command string with the computer keyboard and the system provides output by printing text on the computer monitor (Wikipedia).

Complementary Colours:

Colours that are opposite one another in the colour wheel are called complementary. For example, green is complementary to red.

Desktop Metaphor:

"*The desktop metaphor is a set of unifying concepts currently used in a number of graphical user interfaces in computer operating systems. The monitor of a computer represents the user's desktop upon which documents and folders of documents can be placed. A document can be opened into a window, which represents a paper copy of the document placed on the desktop.* " (Wikipedia)

Graphical User Interface (GUI):

"*Graphical User Interface is the use of pictures rather than just words to represent the input and output of a program. A program with a GUI runs under some windowing system (e.g. The X Window System, Microsoft Windows, Acorn RISC OS, NEXTSTEP). The program displays certain icons, buttons, dialogue boxes etc. in its windows on the screen and the user controls it mainly by moving a pointer on the screen (typically controlled by a mouse) and selecting certain objects by pressing buttons on the mouse while the pointer is pointing at them.* " (Linuxjunkies)

Metaphor:

A metaphor is a figure of speech that implies comparison between two unlike entities, as distinguished from simile, an explicit comparison signalled by the words "like" or "as". The metaphor makes a qualitative leap from a reasonable, perhaps prosaic comparison, to an identification or fusion of two objects, to make one new entity partaking of the characteristics of both. (Encyclopedia Britannica)

User Centered-Design (UCD):

"*User Centered-Design (UCD) is a design philosophy and a process in which the needs, wants, and limitations of the end user of an interface or document are given extensive attention at each stage of the design process. User-centered design can be characterized as a multi-stage problem solving process that not only requires designers to analyze and foresee how users are likely to use an interface, but to test the validity of their assumptions with regards to user behaviour in real world tests with actual users. Such testing is necessary as it is often very difficult for the designers of an interface to understand intuitively what a first-time user of their design experiences, and what each user's learning curve may look like.*" (Wikipedia)

User Interface (UI):

In computer science and human-computer interaction, the user interface (of a computer program) refers to the graphical, textual and auditory information the program presents to the user, and the control sequences (such as keystrokes with the computer keyboard, movements of the computer mouse, and selections with the touchscreen) the user employs to control the program. (Wikipedia)

1.8. Bibliography

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