Navigation - Concepts and Tools

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1. Navigation - Concepts and Tools

Learning Objectives

You will be able...

- ...to distinguish three navigation types for multimedia applications.
- ...to explain some possibilities of how to realise the three navigation types in both, web pages and interactive 2D maps.

Introduction

Where am I?

Have you ever been in a situation where you had to ask yourself "Where am I?" We are sure you were. Everybody gets lost at least once in his/her life.
When you realise that you are lost, what do you do to determine your location? How can you find your way back or the way to continue your journey? Of course we think that it is best to have a map (and to know how to read a map), because with it you are able to determine your position. Since the map shows also the surrounding area of your position, you can determine as well the route that leads to your target location.

If you do not have a map or any other utilities with you that would help to determine your position, you have to orientate you on the objects of your surrounding area (trees, rockets, mountains, high buildings, etc.). Of course, this would not be possible if it were dark or foggy. But we here take for granted that you can see the surrounding and its objects.
The process of estimating one's present position based on various tools - we did not mention all the other tools which help to determine one's position - is called navigation.
Navigation is not only used in the real world but also in virtual environment. The Internet for example is full of *hypertext* [1] and other multimedia applications. You can navigate through them like in real world but you cannot use the same tools as in real space to keep your orientation because in virtual space we have fewer sensors at hand to find our way.
In this virtual environment you can also have the feeling of being lost, because the web sites consist always of more than one object and it is not always easy to keep the orientation.
This lesson will deal with navigation in general and particularly with navigation for multimedia applications. The question how to avoid the "lost in hyperspace" feeling is one of the main part of this lesson. Of course, we do not only talk about the navigation of Internet applications, but also about the navigation in interactive 2D maps.

[1] Hypertext is text which is extended by links. These links act as pointers to other pieces of text that are located elsewhere, either in the same document or in another document or both. Using these links enables users to "browse around" in one or more documents.

1.1. Navigation

Learning Objectives

You will be able...

- ...to explain what navigation is.
- ...to list four senses with which we navigate.

Introduction

This chapter will present answers to the questions:

- What is Navigation?
- How to Navigate?
- Why do we need Navigation?

Did you know that we do not only navigate with our eyes? We will present you a few examples of navigating with other senses that the eyes and explain why we need navigation.

Navigation with Compass (Wikipedia)

1.1.1. What is Navigation?

Definition of Navigation in Real Space

The word navigation is originally a seafaring term. Navigation describes the process of estimating one's present position based on various tools. In earlier times wind, tide and currents acted as navigation instruments and today there are maps, magnetic compasses and even satellite-guided GPS systems that are used as navigation instruments.

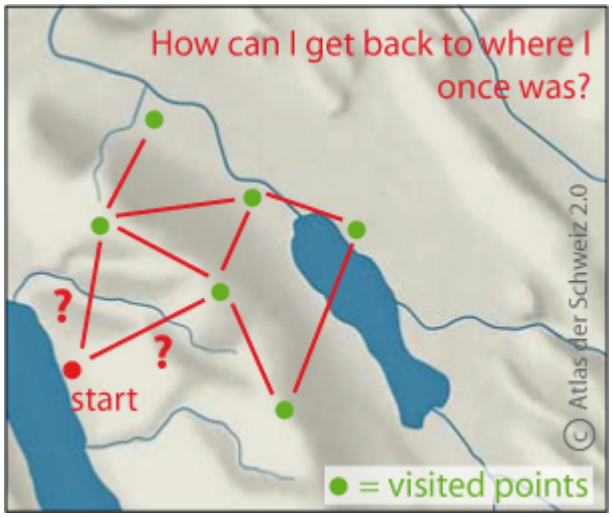
According to (1998), good navigation tools provide answers to questions like:

- Where am I?
- Where can I go?
- How will I get there?
- How can I get back to where I once was?

Where am I?

Where can I go?

How will I get there?



How can I get back to where I once was?

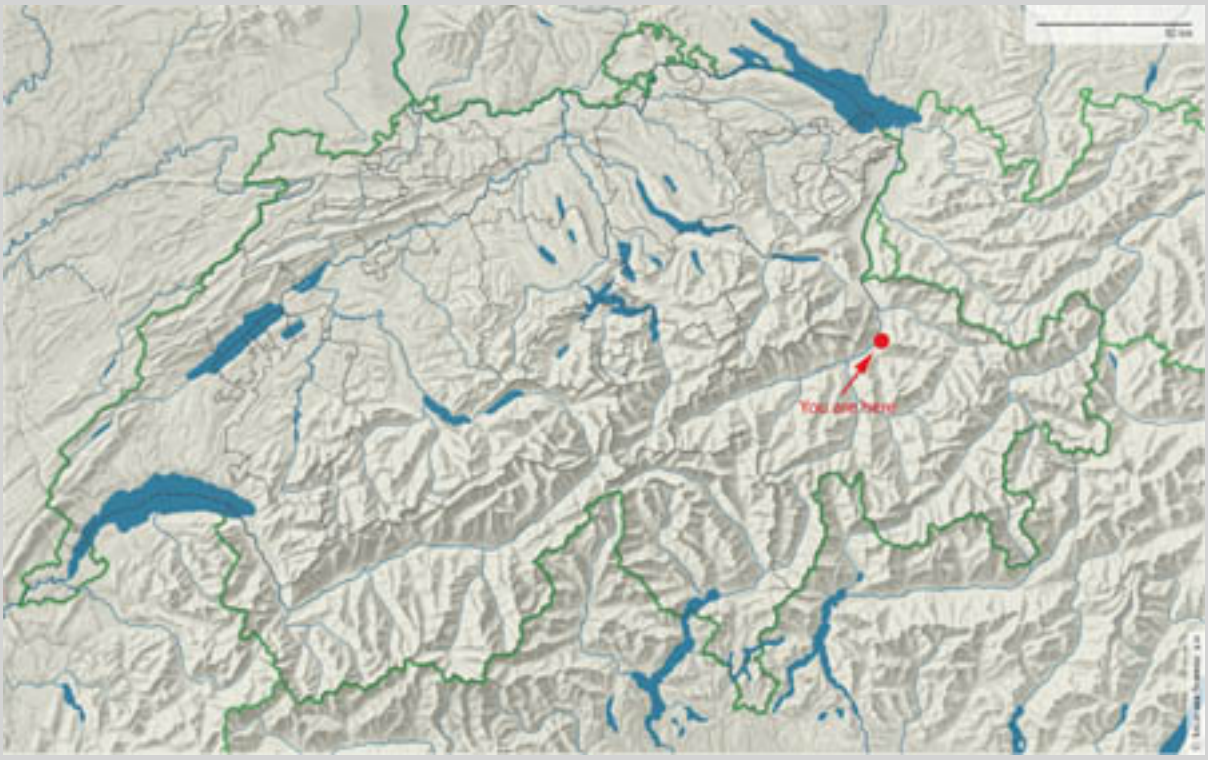
1.1.2. Why Navigation?

Can you tell where the red dot in the image below is located?

Where is the red point?

Even if you knew that the point is located in Switzerland, you would not guess the right location, because there are too few hints (cities, lakes, borders, etc.) that would help to guess the right location.

Click here to see the solution!



Where is the red point?

Do you now know where the red point is situated?
It is near Chur which is the capital city of the canton Grisons in Switzerland.
Supposed you know well the country Switzerland, it is now, when seeing the entire country, easy to guess the right location of the red point. But supposed you do not know Switzerland at all, you still would not know where the red point is located. Perhaps, you would only guess that the red point is in Switzerland.

The presented example of not knowing where we are is not only relating to spatial information but also for multimedia applications in general such as web sites etc. We will discuss these topics in the next unit. We first want to give you an overview of navigation in the real space.

1.1.3. Space Perception

Definition of Space Perception
"*Space perception is a process through which humans and other organisms become aware of the relative positions of their own bodies and objects around them. Space perception provides cues, such as depth and distance, that are important for movement and orientation to the environment.* " (Encyclopedia Britannica)
Humans perceive their environment with various senses. The following senses are responsible for the space perception:

- Sight
- Hearing
- Touch
- Smell

Perception is important for our sense of orientation. Without perception we would not be able to orientate us in the environment and without orientation we are not able to navigate through the space. Therefore, perception is the basis for navigation.
The following paragraphs introduce the four senses that are responsible for space perception. Examples illustrate the use of the senses in real space.

Sight

The most important sense for orientation is the sight. You see objects and you are geared to them. Especially when being on the way and looking for a specific route or destination you orientate yourselve using your eyes.
Have a look at the following example which shows the 360° view on top of the Rossstock, a mountain in Switzerland. You can navigate by clicking and panning the image.

Only pictures can be viewed in this version! For Flash, animations, movies etc. see online version. Only screenshots of animations will be displayed. [link]

Hearing

You perceive with your ears as well. The nature is full of sounds: Ripple of water, singing birds, chirping crickets, ringing church bells, engine noise of the cars, etc. Each sound defines a special area. For example hearing the engine noise of cars means that a street must be very close, the ringing of the church bells are a sign for a near village, etc. The direction where the sound comes from indicates the location of the area.
Explore the sound of different areas in the next example. Click on the icons and listen to the sound that is played.

Smell

The nature is not only full of sounds but also full of odours. You can for example smell the odour of a barbecue or of a bakery from a distance. When you smell such an odour you know that the origin of the odour must be quite close to you. Perhaps you can also identify the direction where the odour comes from.

Because we cannot visualise odours with the computer we count on your imagination for the next example. It shows a small extract of a village. There are three squares marked with red strokes. Move the mouse cursor over these squares to view the odours that are hidden behind these objects. All these odours are perceivable several meters away from the objects.

Touch

Perhaps you sometimes do not realise it but you orientate yourselve often with touching. Most of the time, you touch with your hands to guess an object, but your feet as well give feedback about the features of an object. For example feeling a hard surface under your feet gives you the security to be on a stony ground. You do not know if you are on a man-made street or a natural rock, but you know for sure that you are NOT in the meadow.
Especially for blind people, the touch is the most important sense for orientation. Additional aids such as white canes facilitate the orientation with touch.

Navigation with touch

The ears, the touch and the smell are the most important senses for visually impaired people since they cannot or can hardly use their eyes.

Orientation Problems

Orientation problems arise whenever our surroundings have very few objects which can be used to get our bearings, for example on unknown terrain, in darkness, in the desert or at sea. To be able to orientate us in such terrains, different navigation techniques with different tools emerged. (Studio 7.5 2002)

One of those tools is the map which is a miniature and abstract portrayal of reality (Studio 7.5 2002). They help us to get our bearings because they show the world from a bird's eye view. The next chapter introduces more tools that are used for navigation.

1.1.4. Navigation Tools

There are several different branches of navigation. Each navigation branch uses other instruments (Wikipedia). The following list presents seven navigation branches:

- **Celestial Navigation** - navigation by observation of the position of the sun, moon and stars, and sometimes planets relative to the observer and a known location (Greenwhich Meridian or Prime Meridian).
- **Pilotage** - navigation by using visible natural and man made features such as sea marks (see left image below) and beacons.
- **Dead Reckoning** - navigation by using compass and *log* [2] to monitor expected progress on a journey.
- **Waypoint Navigation** - navigation by using electronic equipment such as radio navigation and satellite navigation system to follow a course to a waypoint.
- **Position Fixing** - determining current position by visual and electronic means.
- **Collision avoidance** using *radar* [3].

Seamark (Wikipedia)

Compass (Wikipedia)

GPS-Satellite (Wikipedia)

Maps as Useful Navigational Aids

To be able to navigate, you do not need a map. But maps are helpful navigational aids which highlight relations between objects of the real space. You can record the information you get from the navigational observations of the introduced navigation branches in a map. With these maps, it is easier to get or keep your bearings.

1.1.5. Unit-Summary

Navigation describes the process of estimating one's present position based on various tools.

Spatial Perception is the basis for navigation. The four senses which are responsible for space perception are: Sight, Hearing, Touch, Smell.

Navigation provide answers to the following questions :

- Where am I?

[2] A log is a device used in navigation to measure the speed of a ship.

[3] Radar is a system that uses radio waves to detect, determine the distance or speed of objects such as aircraft, ships, rain and maps them.

- Where can I go?
- How will I get there?
- How can I get back to where I once was?

There exist several methods to navigate. In this unit we presented you a few of them. Each method uses different navigation tools.

1.2. Navigation for Multimedia Applications

Learning Objectives

You will be able...

- ...to list the three navigation types.
- ...to name at least four principles that lead to successful navigation.
- ...to explain the difference between precise and fuzzy navigation.

Introduction

"*Ironically, the advantage of multimedia, hypermedia and the Web in providing end-users with the freedom of reading, and putting in control to decide which nodes and links to follow, is the very disadvantage of these media that end-users are at the risk of taking the wrong turn or getting "lost". It is possible for end-users to experience this feeling of disorientation even though they may faithfully follow a connected trail of hypertext links, and each link in the trail may make perfect sense. However, by the time end-users are several links deep, the relevance of their current position in the hyperdocument to where they start from may be far from clear.*" (Theng 1999)

Navigating around the Internet and other digital media can be a daunting and confusing experience. We need the digital equivalent of maps, compasses and threads to find our way about and to remember where we have been (Studio 7.5 2002). Without adequate local-global orientation cues, users may suffer from "navigational trauma" and potentially "*lose their sense of place and feel nervous frustration within the zooming space*" (Rodgers 2001) ".
In this unit we want to show you how to avoid the "lost in hyperspace frustration" of your users.

Frustration and Rage when working with computers (Holy Lemon)

1.2.1. Definition

Definition Multimedia Navigation

> Navigation can be described as the task of determining position within the information space and finding the course to the envisaged information and other relevant related information. Navigation helps to explore information spaces that are too large to be conveniently displayed in a single window. The information space consists of spatial, temporal and thematic dimensions. Therefore, one distinguishes between spatial, temporal and thematic navigation. These three modes build on different methodologies and tools, but are closely interrelated. (Neumann 2005)

"*The "Where am I?" question is one of the most basic questions. Disorientation makes people feel insecure. "Lost in Hyperspace" is a common problem of internet surfers and multimedia users, especially for inexperienced ones. In hyperspace and multimedia we have fewer sensors at hand to find our way. Compared to real space, we cannot rely on sensory perception such as touch, balance and smell. The audio is limited and our viewing angle is often narrow. We only see a tiny part of the available information space and usually do not know how big this space is.*
People look for something familiar, for guides and landmarks." (Neumann 2005)

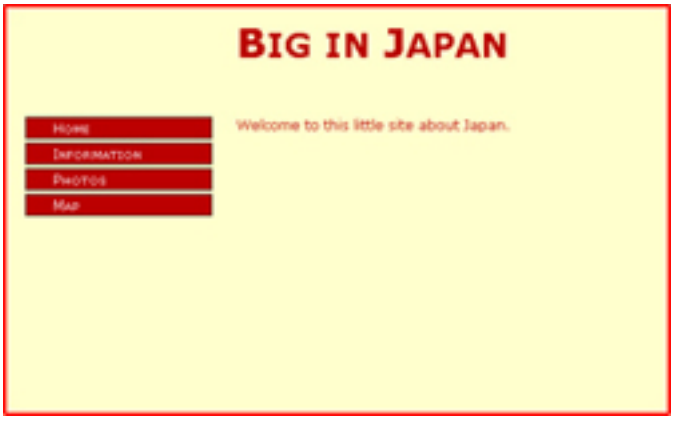
The next chapters present the three navigation types and deal with the question "Which features lead to good navigation for multimedia applications?".

1.2.2. Three Navigation Types

As you could read in the previous chapter we distinguish between spatial, temporal and thematic navigation.

Thematic Navigation

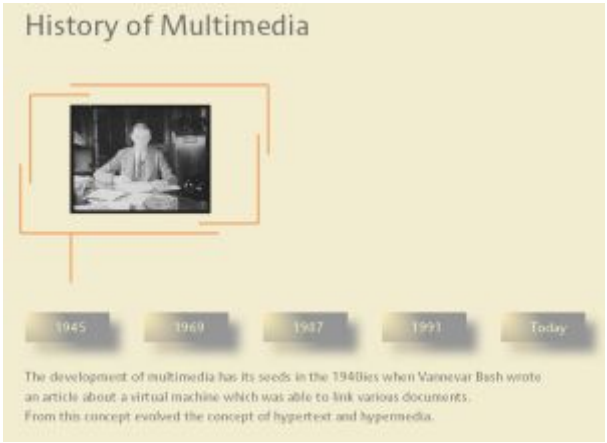
Thematic navigation controls the thematic information of a multimedia application. In web pages this is normally the navigation between different files. In interactive 2D maps, thematic navigation often allows to change the appearing of the map or to extract thematic attributes or values out of the map.



Example of Thematic Navigation

Temporal Navigation

Some multimedia applications contain a temporal component. In each time span (minutes, hours, days, etc.) happened specific events that are visualised in the application. Navigating between these events is temporal navigation.



Example of Temporal Navigation

Spatial Navigation

Spatial navigation is the process of orienting and moving through a virtual environment (University of Edinburgh). Spatial navigation is mainly used in interactive 2D maps as you will see in further chapters.

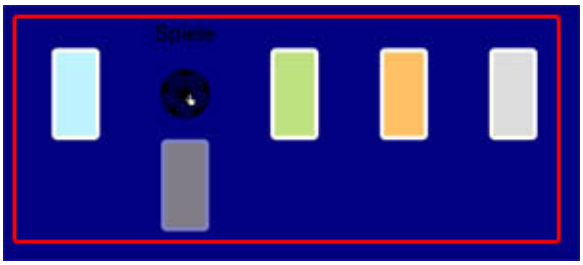
Example of Spatial Navigation

1.2.3. Navigation Features

According to (1998) there exist three criteria that determine the navigability of a space:

1. whether the navigator can discover or infer his present location;
2. whether a route to the destination can be found (successful way finding occurs when the navigator can make correct navigation decisions that take him from his present location to a destination that fulfils his larger purpose.);
3. how well the navigator can accumulate way finding experience in the space.

Good navigation tools guide the user through the information space of a product or web page, helping explore the content and functionalities of a project. Navigation enables exploring information spaces that are too large to be conveniently displayed in a single window. Efficient navigation tools provide both overview and detail. Ideally, multiple user profiles are supported: beginners, intermediates and experts. Experts need more precise and efficient navigation tools and a more direct access to the information offered. (Neumann 2005)
The following examples show a navigation structure for beginners and one for experts. The first example is a screenshot of the **Tirol Atlas for children**. That is why the navigation structure must be easy to learn. The navigation is structured like a memory game. Each colour stands for a theme and the name of the theme appears when moving the mouse over the coloured rectangle. For children which learn better with colours than with written words, this navigation structure makes sense.
The second example shows the web site of the Institute of Cartography of the ETH. Computer skills of the visitors of this site vary strongly. Therefore, we have several possibilities to browse the site. A beginner may not find all navigation features. These features are marked with red frames in the next image. Explore them on the web site of the **Institute of Cartography**!



Navigation for Kids (Tirol Atlas)

Navigation for Adults (Institute of Cartography)

There is no single best, one-size-fits-all navigation method available. The suitability of navigation tools depends on the audience, the user's experience and motivation, the task to solve and the type and size of the information space. A rough rule of thumb is that the larger and more complex the information space is, the more sophisticated and efficient the visualisation and navigation tools should be. Good visualisation systems provide multiple methods for solving the envisaged tasks, supporting different preferences and capabilities of their audience. (Neumann 2005)

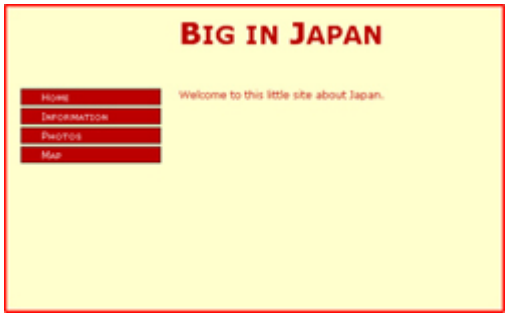
Important is that good navigation provides history and allows to go back to previous information. Additionally, information that has already been visited should be marked.
Navigation tools help to solve spatio, temporal and thematic tasks more efficiently and provide both overview and detail.

1.2.4. Principles of Successful Navigation

Even if there is no optimal technique to realise navigation - according to (1998) - there are some rules which lead to a quality navigation (independent of the technique that is used). We here present you some of those rules.
Navigation should:

- **Be Easily Learned**
  Make your application transparent and obvious to your users. If your visitors have to spend time learning how to use a complex navigation device, they will not have much energy left to absorb your content.
- **Remain Consistent**
  Make sure your approach to navigation is consistent, or you may unwittingly confuse your visitors. The ability to predict where navigation tools will be found is an important first step in making choices.

Non Consistent Navigation



Consistent Navigation

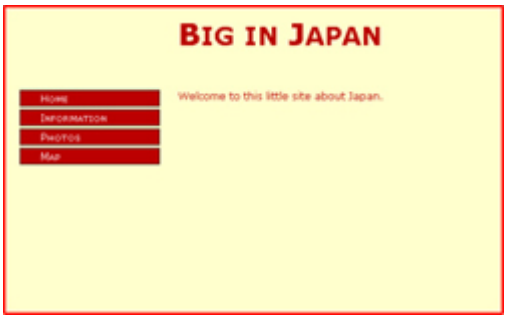
- **Provide Feedback**
  We are conditioned to expect reactions from things. Mouseovers are one good way to provide responsive controls. For example passing your mouse over an object on the screen causes it to "react" - by e.g. Simply lighting it up. Compare the two examples below and find the two implemented feedbacks of the right example.

Which two feedbacks are implemented in the top right example?

- Text Highlighting
- Hand symbol

- **Appear in Context**
  To complete tasks, people need the right tools at hand. To make decisions about movement, they need to see possible routes. Navigation should always be available when it is needed.
- **Require an Economy of Action and Time**
  In cars, planes and on the Web, people lose interest on long trips. A site structure that features layer upon layer of subcategories with many levels to click through can induce "Are we there yet?" syndrome which is roughly synonymous with acute frustration.
  The following two examples contain a map of Japan. We want you to browse to this map. Count the number of clicks you have to do until you reach the map in both examples.

Non Economic Application



Economic Application

How many clicks do you have to do to reach the map in both examples?

- Non Economic Application: 3 Clicks
- Economic Application: 1 Click

- **Provide Clear Visual Messages**
  How you present navigation options is closely tied to how usable they are. If they are hidden, difficult to find, look too much like text, look too much like other images, or are otherwise visually confusing, your users will have trouble getting around. Be aware that interface design is visual guidance. (You will learn more about Graphical User Interface Design in lesson "Graphical User Interface")

Hypertext - Page 1 This is page 1, but you can jump to page 2 or page 3.	Hypertext - Page 1 This is page 1, but you can jump to page 2 or page 3.

- **Use Clear and Understandable Icons**
  Navigation icons are an important part of communication. In selecting icons, it is best to use the terminology of your users, not cool hieroglyphics, office shorthand, or organization-speak. Dead ends and misunderstandings are a waste of time for your users.

Unclear Labels

Clear and Understandable Labels

Because you can never be sure if all users understand the meanings of the icons of your application, there are two possibilities to ensure their understandability:

- Write in letters the function of the icons. See the example of the Atlas of Canada below.

Description of Icon Function Meanings (The Atlas of Canada)

- Implement a tooltip so that the function is described when moving the mouse cursor over the icon.

Description of Icons in Tooltip

- **Be Appropriate to the Site's Purpose**
  Your navigation approach will depend a lot on what your goal is and on what your users will expect to accomplish. A shopping site will not necessarily have the same sort of navigation solution as an information site, for example. Mismatches between the site's purpose and the navigational approach can be a cause for user confusion.
- **Support User's Goals and Behaviours**
  Navigation is about supporting users' goals. What will people want to do? How might they behave? Understanding these goals and behaviours is the most important step in designing navigation that works.

1.2.5. Precise and Fuzzy Navigation

According to (2005) a user can explore an application in two different ways:

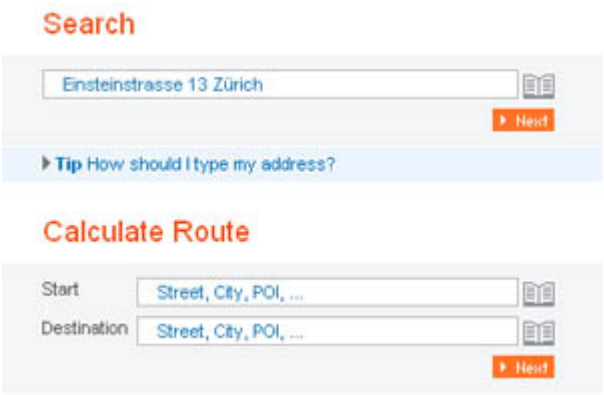
1. **Precise Navigation**: one exactly knows what information is to be extracted out of an application
2. **Fuzzy Navigation**: one wants to explore the application without any specific target.

Precise Navigation

- Precise Navigation on the Internet
  Precise navigation tools let the user quickly go to the location he/she is looking for.
  An example: When you type in the exact URL of a web site in the address bar of a browser, you directly navigate to the desired site. That means you know your target and navigate directly to it.

Precise Navigation in the Internet (Institute of Cartography)

- Precise Navigation in 2-D Maps
  Precise map navigation tools let the user quickly zoom to a map extent that he can specify through coordinates and scale, or addresses.
  The application Map24 is an example for precise navigation. You can type in your address or your start and destination address of an arbitrary route in an input bar and the application will show you the locations in a map as it is shown in the pictures below. Try it out on the **Map24 web site**.



Type in your address or route destinations (Map24)

Map shows result (Map24)

Fuzzy Navigation

- Fuzzy Navigation on the Internet
  In fuzzy navigation tasks the user often does not know exactly where he wants to go, but wants to explore the application visually.
  We use the Google search engine as an example. When you type in an arbitrary term such as "Navigation" you will get many listed results. You then can pick the one you want and go through them unhurriedly.

Fuzzy Navigation in Google (Google)

- Fuzzy Map Navigation in 2-D Maps
  In fuzzy map navigation tasks the user often does not know exactly where he wants to go, but wants to explore the map visually.

Explore the map

1.2.6. Summary

Three Navigation Types

Navigation for multimedia applications can be subdivided into three types:

- Thematic
- Temporal
- Spatial

Navigation Features

There is no single best, one-size-fits-all navigation method available. The suitability of navigation tools depends on the audience, the user's experience and motivation, the task to solve and the type and size of the information space. But there are a few rules that have lead to good navigation:

Good navigation tools guide the user through the information space of a product or web page, helping explore the content and functionalities of a project. They are intuitive and do not force the user to first study extensive manuals or help documents. They are consistent throughout the whole product. This includes the appearance (e.g. Colours and fonts), the placement and the functionality of the tools. Navigation elements should not be dominant in screen layout. (Neumann 2005)

Precise and Fuzzy Navigation

A user can explore an application in two different ways:

1. One exactly knows what information is to be extracted out of an application, what is called **precise** navigation,
2. One wants to explore the application without any specific targetwhat is called **fuzzy** navigation.

1.3. Thematic Navigation

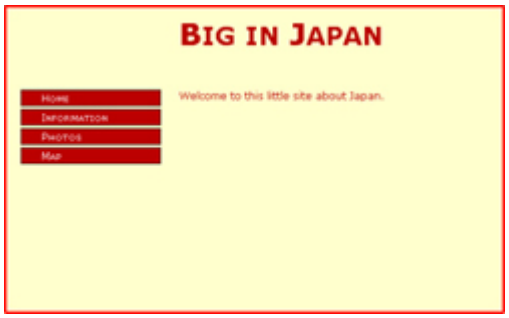
Learning Objectives

You will be able...

- ...to distinguish between sequential and non-sequential navigation structure.
- ...to list three thematic navigation structures for Web Pages.
- ...to name at least three possibilities how thematic navigation can be relised in 2D maps.

Introduction

"*There are a lot of wonderfully unpredictable folks out there creating wonderfully unpredictable sites that are based on personal whims, not balanced and thoughtful presentation. Their sites work just fine for them. The problem is they do not work for anyone else. The context is often weak. Relationships between information objects are unclear. Most visitors end up feeling as if they have been asked to solve some devilish riddle, when all they came to do was find a piece of information.*" (Fleming 1998)



Thematic Navigation

In this unit we want to show you that not every web page has to end up as it is described above. A good thematic navigation helps the users to find their way through an application.
Thematic navigation is not only used in web pages but also in interactive 2D maps. Most of these maps are thematic maps whose themes can be changed or modified.
We here show you a few possibilities of how to realise thematic navigation in interactive 2D maps.

1.3.1. Thematic Navigation Technique and Structure

Optimal Technique for Thematic Navigation?
The optimal technique for navigation in a topic depends very much on the data type, the size of the information space to be visualised as well as on the user profiles. User profiles are brief studies of the sort of person who might visit your application (Fleming 1998). It is difficult to predict what people might want and expect from an application, and how they would behave. Different users which visit one and the same application may have different goals what impacts on the navigational behaviour of a user. Also the skills one has in computers, impacts greatly on the behaviour of a user.
Since the user profiles vary greatly, there are no simple recipes for navigation design. Therefore, we cannot recommend THE optimal technique for thematic navigation. That is why we introduce you several possibilities how to realise the thematic navigation of an application.

Thematic Navigation Structure
We mainly differ two navigation structures: Sequential and Non-Sequential structure:

- **Sequential Navigation Structure**
  The user is forced to browse through intermediate steps before reaching his destination.
  Sequential navigation is hardly used any more for Web Pages, because the user has no liberty to choose his way through the page as you can see in the following example.

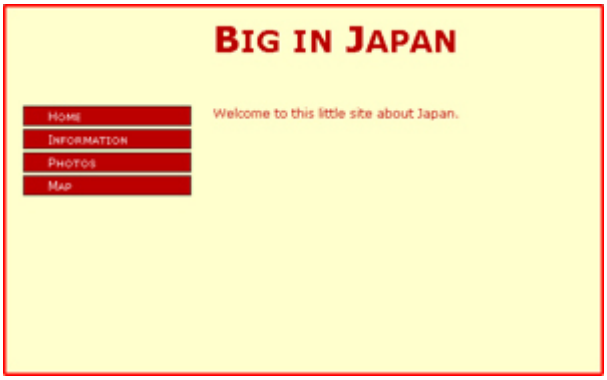
Sequential Navigation Structure in Web Page

It is more common though, to implement sequential navigation into thematic interactive maps. Within such applications it is sometimes necessary that the user chooses the selections in a predefined order. An example is the application **"Map Symbol Brewer"** with whom you are able to create different diagrams for a map. Here it is important that all parameters are defined one after another and in the predefined order.

Sequential Navigation Structure in 2D Map (Schnabel 2006)

- **Non-Sequential Navigation Structure**

  Non-Sequential navigation allows the user to "jump" instantly to a new location as it is shown in the following example.



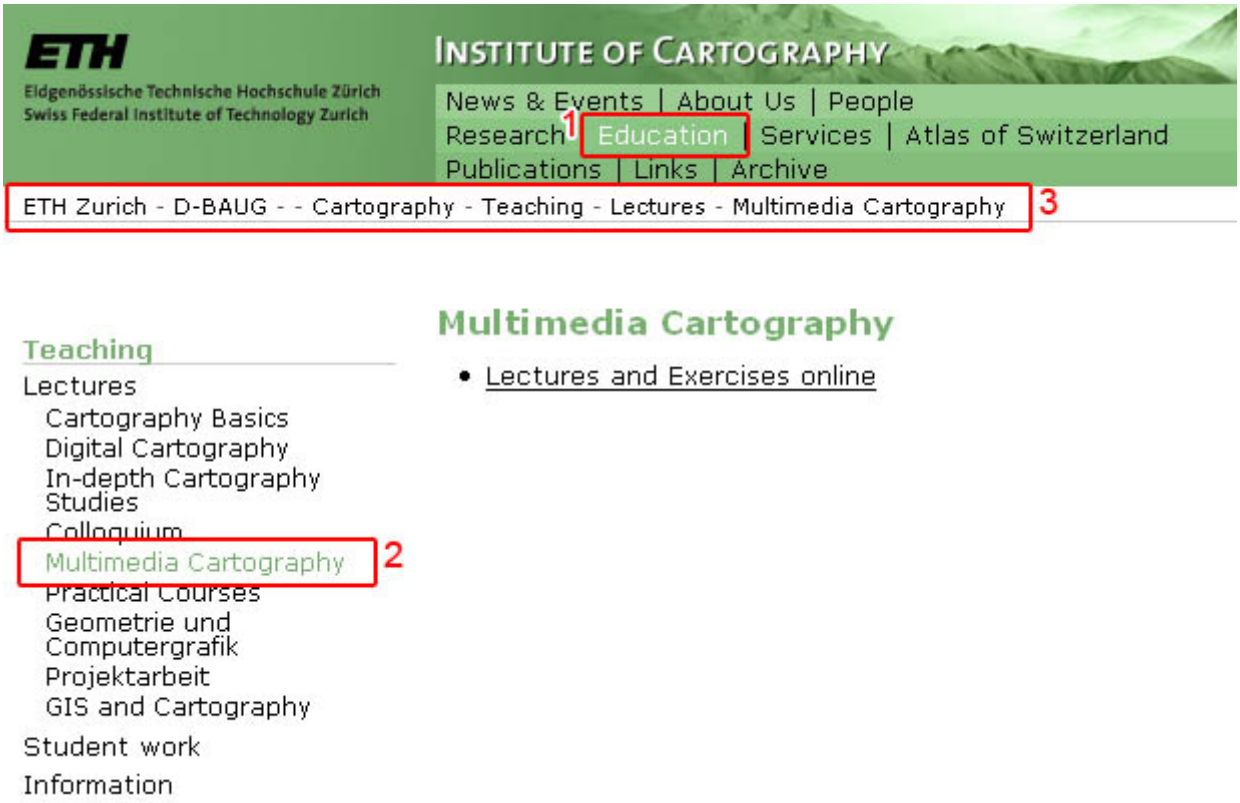
Non-Sequential Navigation Structure in Web Page

This method is used for most applications. The advantage is that the users are free to find their own way through the application.

History Function

A history function allows the user to go back to previous views. Particularly for web pages which contain a huge amount of linked information, this function is strongly recommended. Additionally, information that has already been visited should be marked.

The following image shows how the web page of the **Institute of Cartography** of the ETH Zurich marks the information that has already been visited. In the main navigation menu the selected theme is marked in white (1). The sub menu "Teaching" marks the selected theme in green (2). And last but not least, all selected themes are listed sequentially in a breadcrumb navigation bar (3). This bar is normally interactive so that the user can go back to the theme of his choice.



Visited Links are marked in other colours

A history function is already implemented in the navigation bar of each browser. You there find forward and backward buttons which allow you to switch between the information that you have already visited. The history function saves the path of the visited files. That is why you can go back to previous information. When you go back, you always have the possibility to return (now: go forward) to the file you have visited as last.

The following image shows the history functions of the browser Firefox.

History Function in Firefox (Mozilla Firefox)

In the Opera browser you even have the possibility to choose between several history buttons. The functions of the buttons are explained in the right image below.

History Function in Opera (Opera)

Image	Item	Explanation
	Back Forward	Go back and forth in page history
	Fast forward	Analyze page and go to the most likely next page. a. Follows `link rel="next"` in page header. b. Follows link in page with text "Next page" or similar. c. Starts slideshow if page contains links to multiple images.
	Rewind	Jump back in history a. Go to entry page on this site b. Go to exit page on previous site (if on entry page)

Explanation of Opera's History Functions (Opera)

Take into account that you cannot use the browser's predefined history functions for each application. E.g. within SVG or Flash applications, you have to create your own history functions because you browse inside your file and not, as normally in web browsers, between different HTML files.

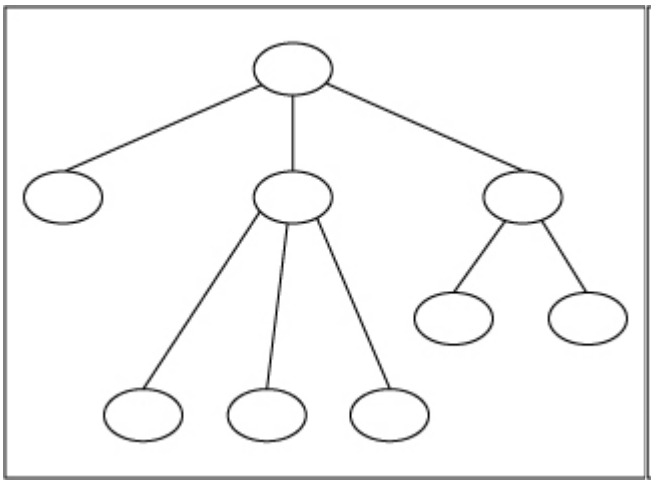
1.3.2. Thematic Navigation for Web Pages

Thematic navigation is the most important navigation type for Internet applications and has become a must-have for web pages.
As we already told you, sequential navigation is hardly used anymore for web pages. Therefore, we want to deepen the non-sequential navigation structure.
The non-sequential structure can be subdivided into two subgroups. Basically, one can distinguish between:

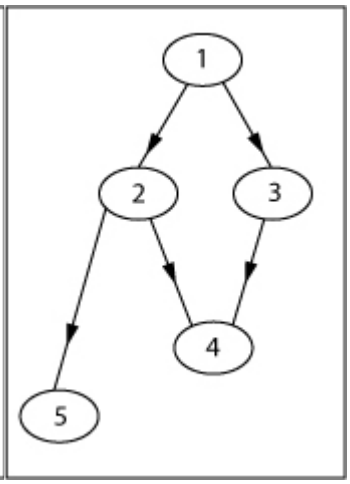
- Hierarchic Structure
- Network Structure

Hierarchic Navigation Structure
"*Hierarchic tree structures are collections of items, in which each item (except the root) has a link to one parent item.*" (Plaisant 2005)
According to (2005) we distinguish between two hierarchical trees:

- **Top-Down Hierarchical Tree**
  The main topics are at the top, and other topics below. There is a single direction to browse through the tree (top-down). The main feature for this form of structure is that either the graph has no cycles, or that nodes participating in cycles are ordered (Rodgers 2005). The right image below shows such an ordered cycle. Important is, that it is NOT possible to reach node 3 by starting at 1 and passing the nodes 2 and 4. We only reach node 3 from node 1.

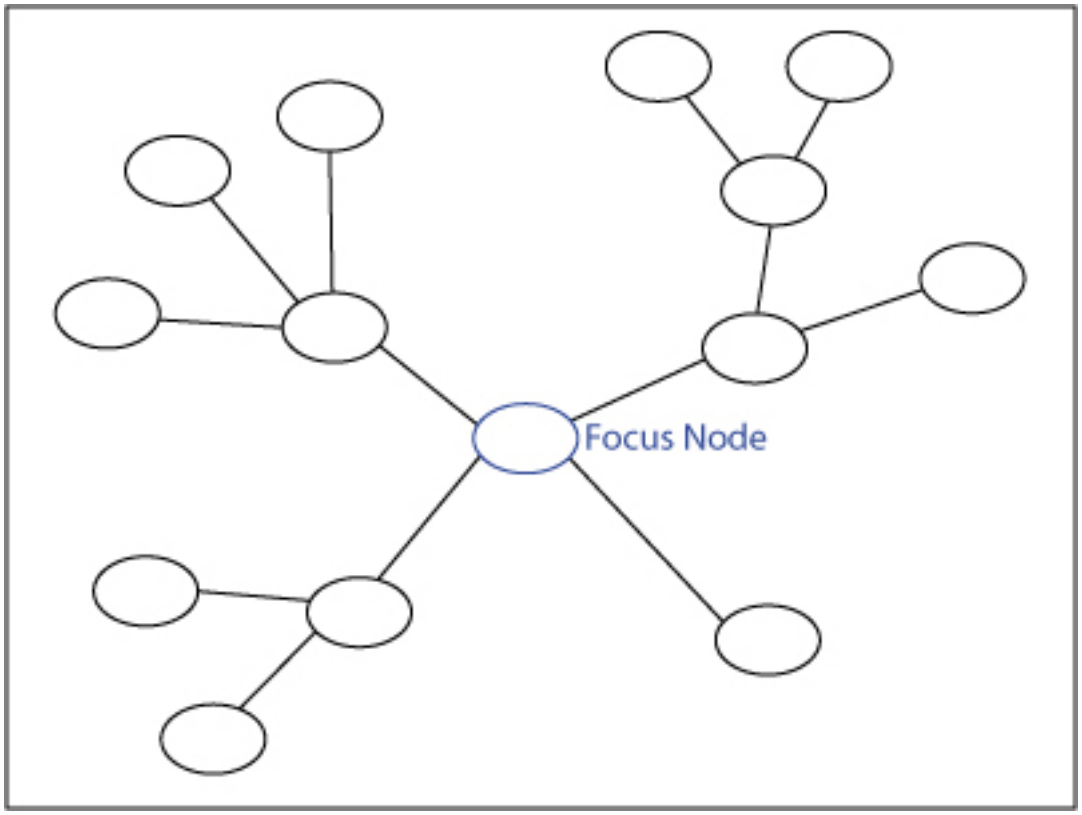


Top-Down Hierarchical Tree



Ordered cycle (going back is not allowed)

- **Radial Hierarchical Tree**
  The tree is rooted at the focus node (center of interest/focus of attention) and the other nodes are layed around this node. Lines are drawn to show the parent-child relationships between the nodes. (Yee et al. 2001)
  In contrast to the top-down hierarchical tree, you are able to jump directly from one child node to another child node without passing the focus node. You will see that in the example we show you below.



Radial Hierarchical Tree

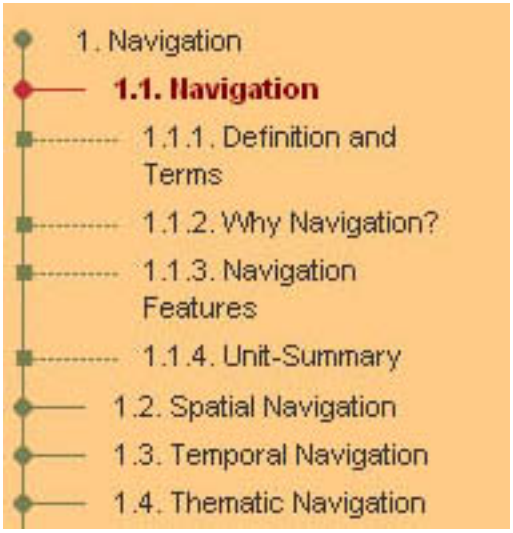
Hierarchic thematic navigation is often visualised using interactive trees where one interactively opens and collapses sub-hierarchies.

Examples of Top-Down Hierarchical Trees

A typical example for a hierarchical top-down tree structure is the *file-browser* [4] (Neumann 2005).

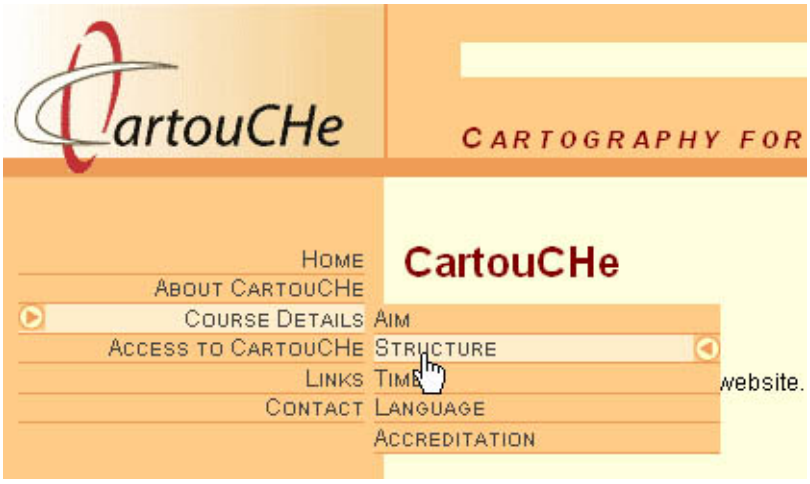
[4] A file browser is a computer program that provides a user interface to work with file systems. They are very useful for speeding up interaction with files. The most common operations on files are create, open, edit, view, print, play, rename, move, copy, delete, attributes, properties, search/find, and permissions .

The navigation of the Cartouche e-learning lessons have the same hierarchy as the mentioned file-browser. The navigation on the left, which you can explore by your own, allows you to open and collapse sub-hierarchies (in our case the different units with their learning objects).



Hierarchic Navigation of Cartouche Lessons (Cartouche)

Another example that features a hierarchic navigation was the old Cartouche Web Page. When moving the mouse cursor over the thematic topics, the sub themes (if there are some) appeared.



Old Cartouche Web Page (Cartouche)

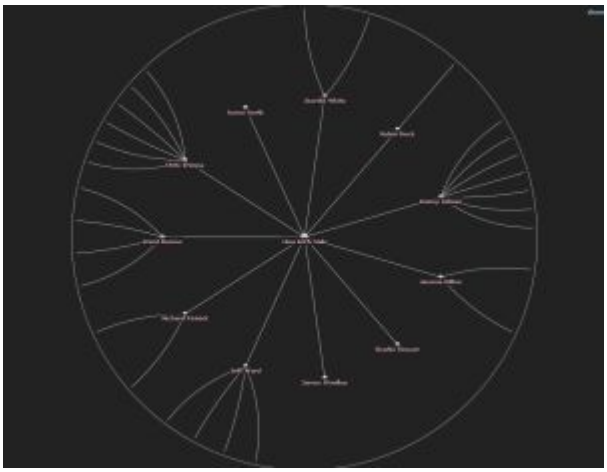
We will not list more applications with hierarchical top-down tree structure, because the Internet is full of them. This method is often used, because persons who work with the computer are already used to this method since they all use the standard file-browser which has the same hierarchic structure.

Example of Radial Hierarchical Tree

An example of a radial hierarchic tree is the hyperbolic browser developed and propagated by the company Inxight (Neumann 2005). The software enables you to link files, documents and Web pages. It provides a visual context for information, showing at-a-glance hierarchical relationships (Inxight). Within the tree, items can be interactively moved to the center of the visualisation. Objects farther away from the visualisation center are perspectively scaled down and later hidden (Neumann 2005).

Hyperbolic browser of the Inxight Company (Inxight)

There are a few examples on the **JIT Blog** which demonstrate the use of a hierarchical radial tree. Explore one of the following examples by clicking on the thumbnails:

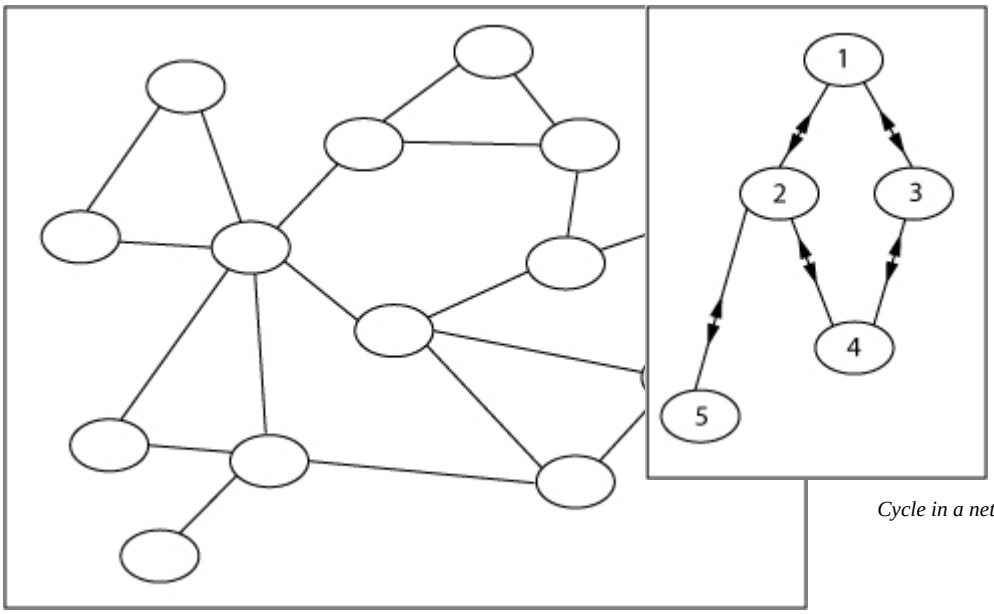


JIT Hyperbolic Tree (Belmonte)

JIT Radial Graph (Belmonte)

Network

When relationships among items cannot be captured conveniently with a regular tree structure, items are linked to an arbitrary number of other items in a network. Network visualisation is an old but still imperfect art because of the complexity of relationships (Plaisant 2005). In contrast to hierarchic trees networks have cycles. These cycles are not ordered as in the hierarchical tree. The right image below shows such a cycle. You can reach node 3 either from node 1 OR node 4.

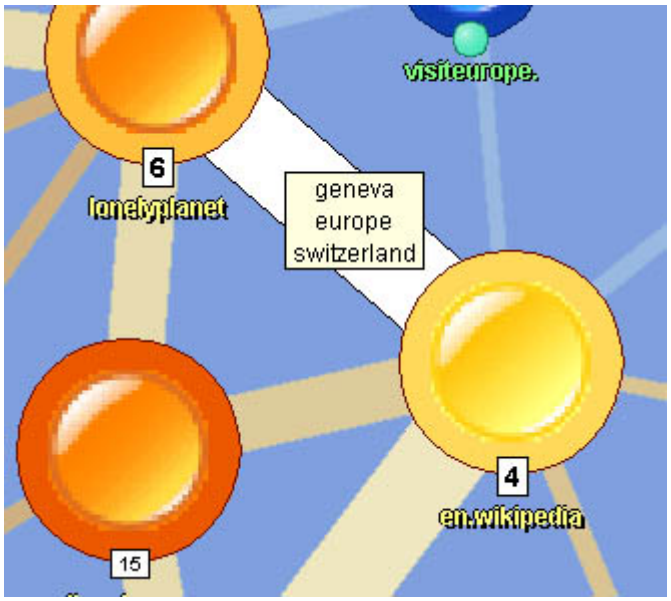


Cycle in a network

Network

The search engine MapStan visualises the search results in an interactive network. As soon as you launch a search, the search engine analyses your request, questions the search engine Google, selects the best sites and places them on a map." *MapStan Search displays your search results on a "district map" where the pages are grouped by site. Squares represent sites and are linked by streets that indicate their similarity. When several sites are always linked in the same searches, they are grouped within a single square. In this way, you get a visual synthesis of your results and of the proximity between pages.* " (MapStan Search)

MapStan Search Engine (MapStan Search)



Street representing the relationship between the sites that it joins (MapStan Search)

Explore the **Relation Browser** made by (2006). Click on the different countries and note how the visualisation of the relations changes.

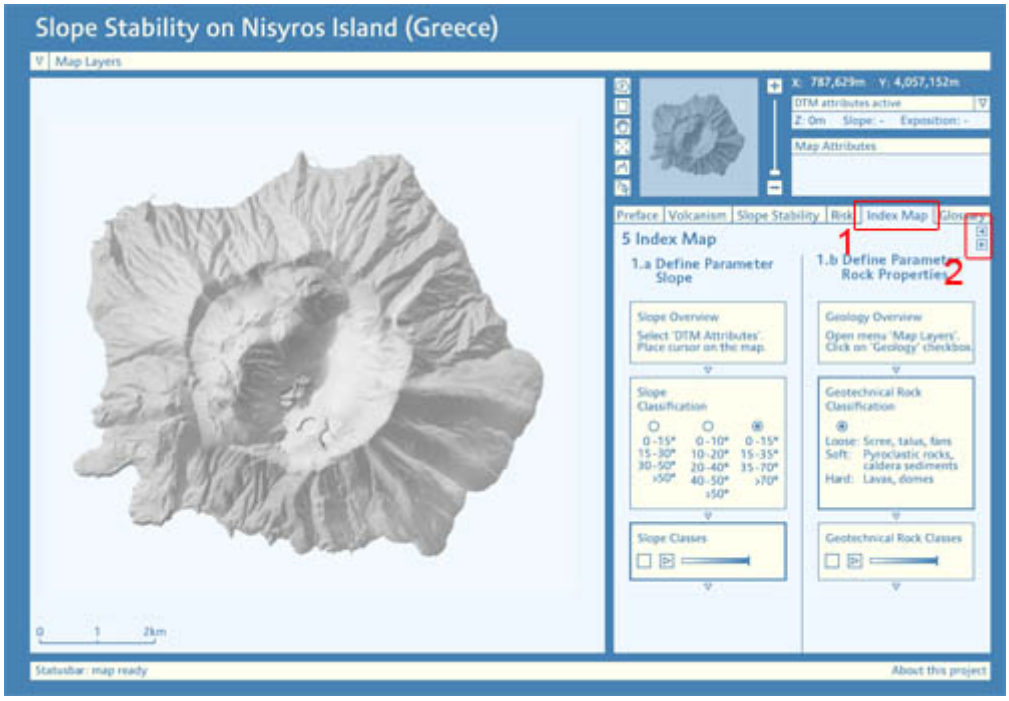
Exercise
Study the navigation structure of five of your most preferred web pages that you visit very often. Define the structure of their thematic navigation and give reasons about your decision. Put the links to these sites and your results on the discussion board "Navigation Structure". Pick five of the web pages that your colleagues put on the discussion board (mustn't be the same as your web pages) and study their navigation structure. Comment on five entries of your colleagues. Do you agree with the result of your colleague or do you have another opinion of the web page's navigation structure?

1.3.3. Thematic Navigation in 2D Maps

Not every interactive 2D map features thematic navigation because the map must be about a topic. Therefore, in many cases maps that feature thematic navigation are thematic maps. There is one main exception: Topographic maps can feature Map Layer Control Tools (you are able to switch on and off layer of certain topics) which are part of the thematic navigation. It is more common to implement sequential navigation structure in interactive maps than in web pages. We here present you some examples:

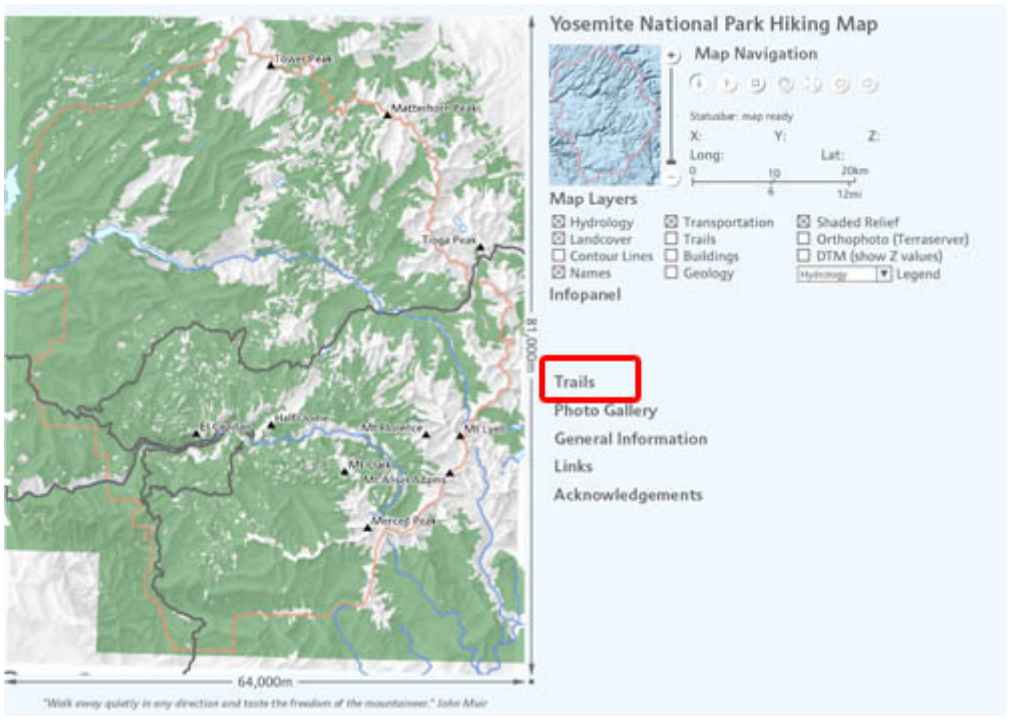
Sequential Structure

- **Slope Stability on Nisyros Island**
  There is the menu "Index Map" (1) where you can create a slope stability Index Map. It is a step-by-step procedure to determine the slope stability on Nisyros Island combined with areas relevant to damage potential. The procedure starts with the definition of input parameters. The next step is called with a "Forward" button (2).



Slope Stability on Nisyros Island (Flüeler 2005)

- **Yosemite National Park Hiking Map**
  In the menu "Trails" you can visualise hiking trails in the Yosemite national park. The trail has to be defined in two to three steps: You can choose a trail due to its name, difficulty, duration or location. Step-by-step you can select different attributes.



Yosemite National Park Hiking Map (Williams 2005)

Even if there are some interactive maps that feature a sequential structure as thematic navigation, it it more common though to implement a non-sequential structure as thematic navigation. The next examples present you some of those maps.

Non-Sequential Structure

- **Map Layer Controls**
  We already discussed this technique in former lessons. You are able to switch on and off various thematic layers by clicking on the checkboxes. You do not have to follow a specific order to switch on and off the individual layers.

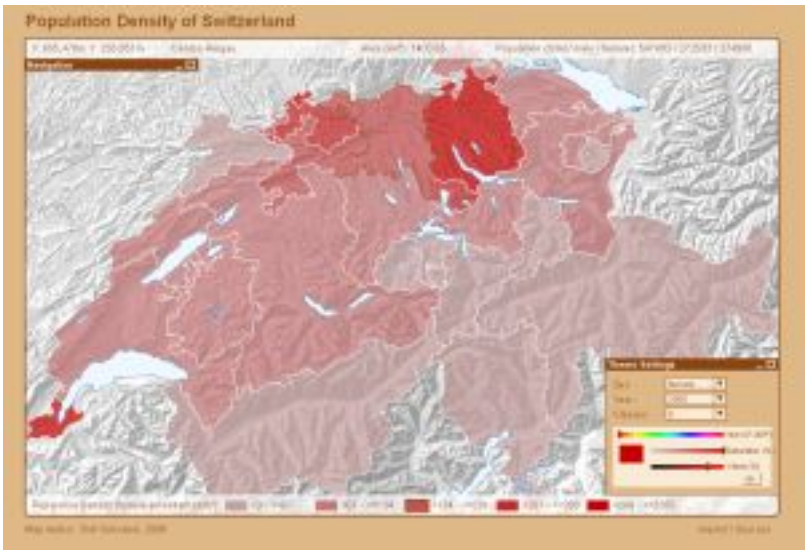
Map Layer Controls

- **Show Attributes on Mouse Over**
  A common way of thematic navigation in interactive maps is showing additional thematic information with "on mouse over" and "on click" events.

The next example shows the energy consumption and hydrologic powerplants in the USA. The estimated energy consumption per state is visualised with a histogram when moving the mouse over a state. Additional information about dams are viewed when clicking on the dam feature.

On mouse over and on click events (Burger et al.)

- **Selection Lists and Radio Buttons**
  This application visualises the population density of Switzerland in the years 1970-2000. You can select various settings in an arbitrary order.



Interactive choropleth map (Schnabel 2008)

1.3.4. Self Assessment

We here list a few web pages that feature a special thematic navigation. You have to define the non-sequential navigation structure (Top-Down Hierarchical Tree, Radial Tree, Network) for each web page.
Explore the applications and think about which structure the websites feature. The popup-windows below the thumbnails contain the solutions. Be honest with you and do not open the popup window until you thought about the navigation structure. You reach the websites by clicking on the thumbnails.

Relevare

This is a website of the company of the same name. The zoom is used as the navigation element. The four quadrants represent the main categories of the site. The user clicks to zoom into individual areas. The zoomed path is shown at the bottom edge as an extra navigation bar.

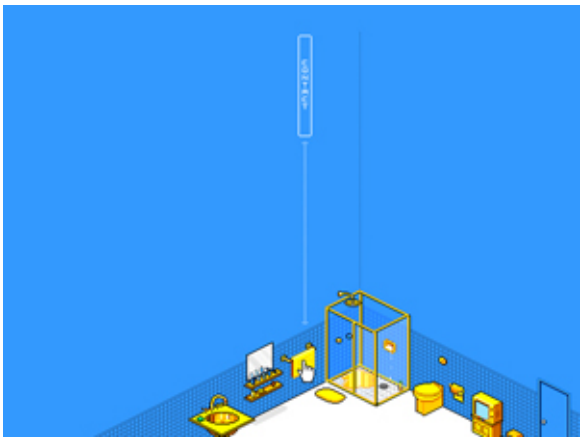
Web Site of "Relevare" (Relevare)

Click here AFTER exploring the application to see the solution!

Top-Down Hierarchical Tree

Golden Shower

Golden Shower is the website of a music project. For the main navigation level a bathroom is shown (see image on the left). In the subsequent menu, this introductory navigation is only indicated by extracts (see image on the right).



Web Site of "Golden Shower" (Relevare)

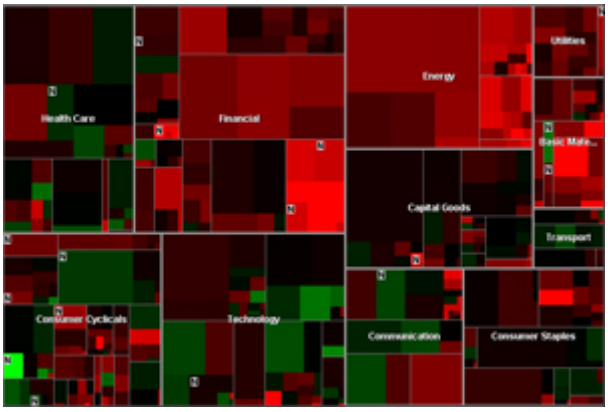
Subsequent Menu (Relevare)

Click here AFTER exploring the application to see the solution!

Top-Down Hierarchical Tree

Map of the Market

Market Map is a website which visualises stock market data in a mapping structure. This presentation provides an immediate overview of the present state of the market. More detailed information can be called up when necessary by clicking on a field and choosing a theme out of the dropdown menu.



Map of the Market (SmartMoney)

Click here AFTER exploring the application to see the solution!

Top-Down Hierarchical Tree

Thinkmap Visual Thesaurus

The Visual Thesaurus is a dictionary and thesaurus. It displays words and meanings that are related to the item in the center of the display. Clicking on a word brings it to the center of the window. (Visual Thesaurus)

Type a word into the text box at the top of the page and click "look it up". The location of the text box on the web site is shown in the left image below.

Where to enter the application (SmartMoney)

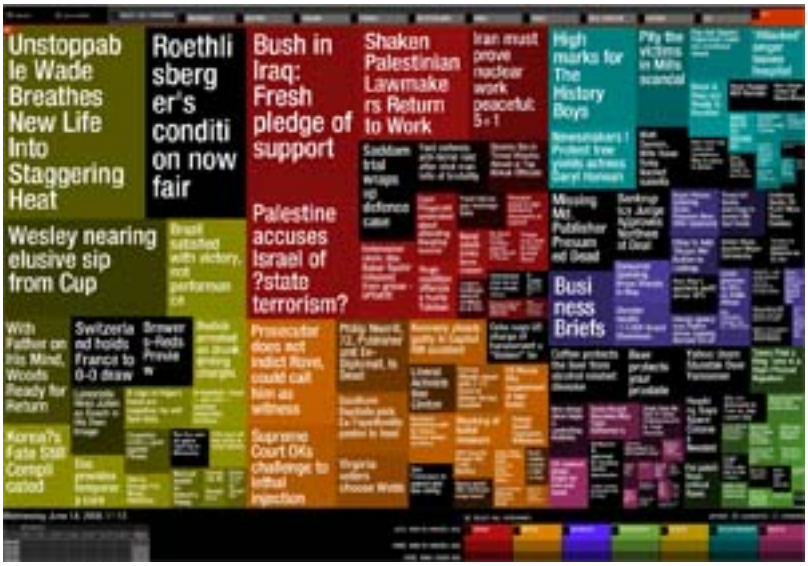
Visual Thesaurus (SmartMoney)

Click here AFTER exploring the application to see the solution!

Radial Hierarchical Tree

Newsmap

The Newsmap gathers stories from thousands of news sources worldwide, and automatically arranges them to present the most relevant with the largest font-size. The topics are divided into seven groups which are distinguished with different colours. You can click on the item that interests you and you'll go directly to the site which published that story.



Newsmap (Weskamp et al.)

Click here AFTER exploring the application to see the solution!

Top-Down Hierarchical Tree

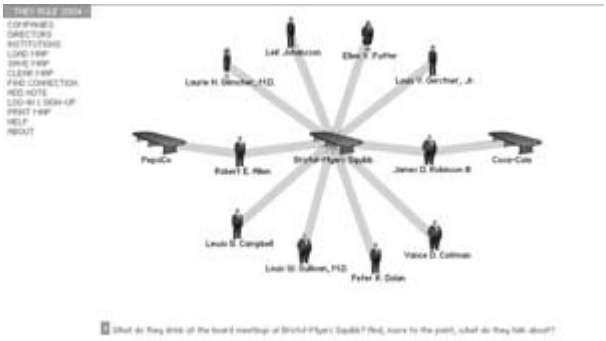
They Rule

"*They Rule aims to provide a glimpse of some of the relationships of the US ruling class. It takes as its focus the boards of some of the most powerful U.S. companies, which share many of the same directors. Some individuals sit on 5, 6 or 7 of the top 500 companies. It allows users to browse through these interlocking directories and run searches on the boards and companies.*" (They Rule)

The links between individual companies are interactively visualised; additional information about the responsible persons can be called up, or a search on Google can be initiated when clicking on the tables that represent the companies or the persons.

You first have to click four times somewhere in the window during the intro session of the web site to reach the real web site. You then can load several maps, recent and popular ones under "Load Map"

Where to load the map (They Rule)



Visual Thesaurus (They Rule)

Click here AFTER exploring the application to see the solution!

Depending on the map: Radial Hierarchical Tree, Network

Kartoo

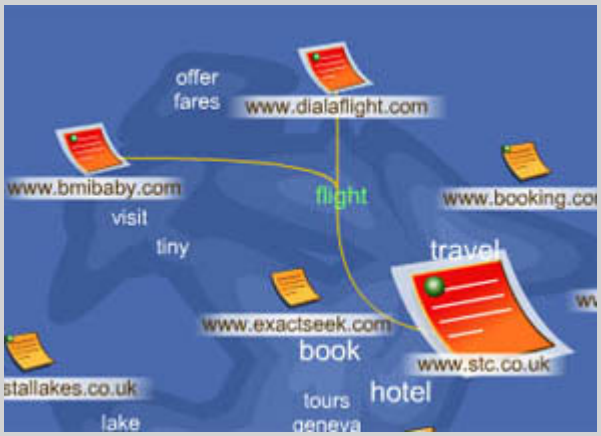
"*Kartoo is a meta search engine which presents its results on a map. As soon as you launch a search, Kartoo analyses your request, questions the most relevant engines, selects the best sites and places them on a map.*
In this map, the found sites are represented by more or less important size pages, depending on their relevance. When you move the pointer over these pages, the concerned keywords are illuminated and a brief description of the site appears on the left side of the screen." (Kartoo)

Kartoo Visual Meta Search Engine (Kartoo)

Explore the search engine: type in a few search terms and study the results.

Click here AFTER exploring the application to see the solution!

Top-Down Hierarchical Tree.
Did you think it was a network? It looks like a network at the first glance but when studying carefully the navigation structure we realise that it is a top-down hierarchical tree structure. Have a look at the following images.



First Keyword (Kartoo)

Second Keyword (Kartoo)

You can see that the "bmibaby.com" website is connected with the two keywords "flight" and "tiny". It therefore seems to be a network. But when you click on the keyword a new search is started and you get a new map with other results. You are not able to get back to the previous view anymore. You only dig deeper and deeper in the map without having a possibility to go back (Deleting terms in the input bar does not count as a navigation tool). Therefore, it is a top-down hierarchical tree structure with ordered cycles.

Grokker

Grokker is search engine which presents its results either in text form or in a map. In this map, the results are represented depending on their relevance; important objects appear first, less important ones only after zooming into the information space. Objects that are closer to each other are grouped in "galaxies", in which the user can dig into deeper, gradually revealing more details (Neumann 2005). Filters help you pinpoint specific information in your results.
When you move the mouse cursor over the located pages, additional information of the page appears in a tool tip and the link to the pages appears.

Grokker Enterprise Search Management (Grokker)

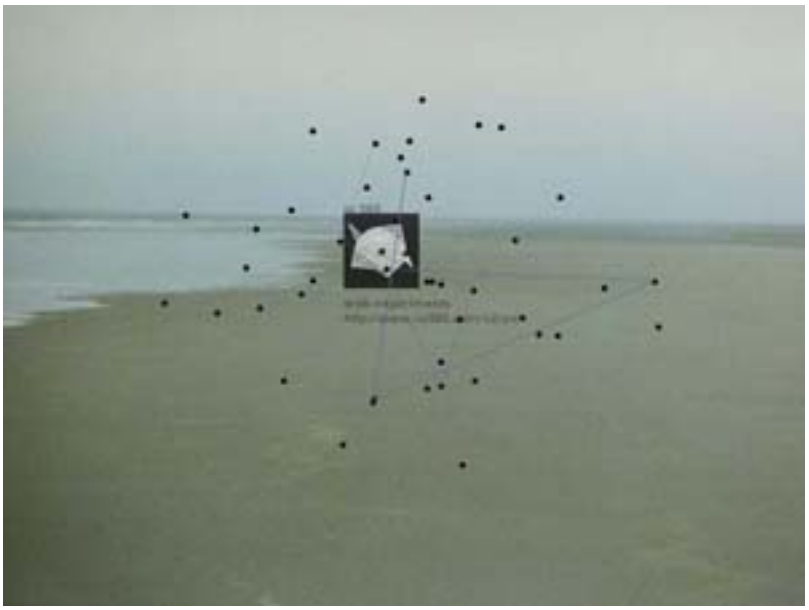
Explore the search engine: type in a few search terms and study the results. You have to click on "Map View" to reach the map view of your search.

Click here AFTER exploring the application to see the solution!

Top-Down Hierarchical Tree (visualised in a special way)

Sinnzeug

"*Sinnzeug is a novel dynamic search-engine for links to intelligent websites we think are worth spending time on. Each dot on the screen represents a website. After doubleclicking anywhere in the window you can enter a cueword or choose one from the popup-menu. You can start your individual search for the websites you are interested in by placing an index of catchwords in the window and arranging them.*
The websites i.e. the dots that feel they have something to do with this word will be attracted by it. To remove a cueword just drag it out of the window. " (Huber et al.)
The exploration of this example is optional and can be skipped. It works only on Internet Explorer and need the **Shockwave Plugin**. If you want to explore it, you have to click on the "Please enter" button to reach the application.



Web Site of "Sinnzeug" (Huber et al.)

Click here AFTER exploring the application to see the solution!

Network

1.3.5. Unit-Summary

Thematic navigation structure can be subdivided into

- Sequential Navigation, which forces the user to browse through intermediate steps before reaching his destination.
- Non-Sequential Navigation, which allows the user to "jump" instantly to a new location.

Sequential navigation structure is mainly used in interactive 2D maps, where it is necessary that a user goes through different steps chronologically. Within web pages it is not convenient to be forced to go through the information step-by-step. Imagine you are looking for specific information and you have to click twenty times to finally reach the wanted location.

Thematic Navigation for Web Pages
As we already told you, sequential navigation is hardly used anymore for web pages. But the non-sequential structure can be subdivided into two subgroups:

- Hierarchic Data Structures
- Network Data Structures.

Thematic Navigation for 2D Maps
Within interactive 2D maps there exist both, sequential and non-sequential structure. The decision of which structure is better for an interactive 2D map depends on the topic and the target of the application.

1.4. Temporal Navigation

Learning Objectives

You will be able...

- ...to list at least five time control tools.
- ...to list two possibilities how temporal navigation can be realised in web pages.
- ...to list three possibilities how temporal navigation can be realised in web pages.

Introduction

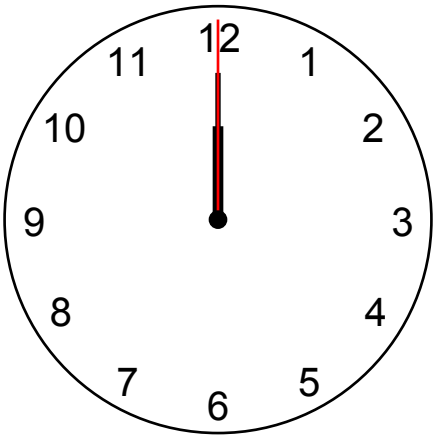
Time defines our life. Our whole life is based on time. A year consists of 12 months, a month consists of 28-31 days, a day consists of 24 hours and so on. We (normally) sleep at night and stay awake during the day. Days, months and years pass by while things are happening.
The question "When happened what?" is a basic question in our real life. You cannot just tell somebody "there was an earthquake" without any time declaration. The earthquake could have happened ten year ago or just last night.
Not only in real life but also in virtual environment time is a very important factor. When you save a document, the time of the saving action is saved as well. This time is very important when you have for example two documents with identical names and you are looking for the newer one. Only the saved time gives you information about which document is the newer one.
Within multimedia applications, time can be important as well. Here too, the question "When happened what?" is the most important question concerning the time aspect. Therefore, time is always coupled with a topic. In other words: there is one layer for each time segment. To keep one's orientation between these layers we need temporal navigation.
In this unit, we show you some possibilities how temporal navigation can be realised within web pages and interactive 2D maps.
The following interaction part is only an example of a temporal navigation and is about the history of *typography* [5]. You do not have to read all the text within the example but you should explore the interactive time line.

Only pictures can be viewed in this version! For Flash, animations, movies etc. see online version. Only screenshots of animations will be displayed. [link]

1.4.1. Time

Definition
Time quantifies or measures the interval between events, or the duration of events and has only a "forward direction". Time features different granularity e.g. seconds, minutes, hours, days, months, years, centuries, etc. (Neumann 2005)

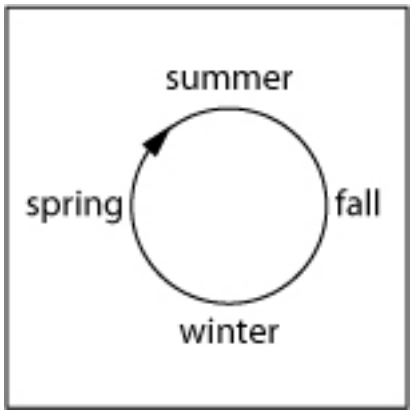
[5] Typography is the art and technique of selecting and arranging type styles, point sizes, line lengths, line leading, character spacing, and word spacing for typeset applications. These applications can be physical or digital.



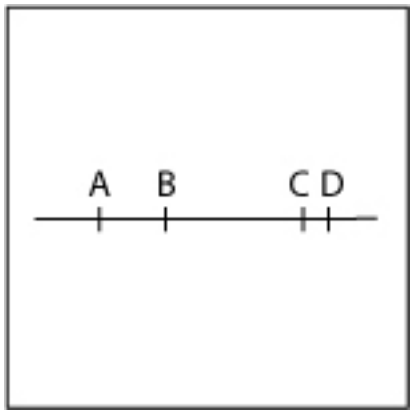
Conceptualizing and Modeling Time

(1998, p. 45) mainly distinguishes between linear and cyclic time:

- **Cyclic time** is used in case of reoccuring events and needs to be brought into relation with an absolute.
- **Linear time** scale is used for accurate calculation against an origin.



Cyclic Time according to Frank 1998



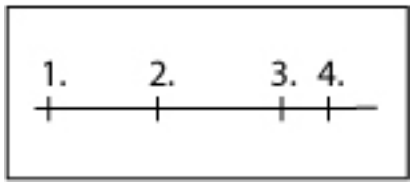
Linear Time according to Frank 1998

Depending on the accuracy of time observations and measurement one can subdivide the two time types into:

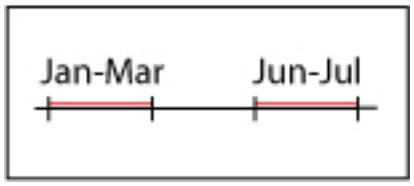
- *Ordinal* [6]Time: time points are the basic objects to describe the time an event happened (Frank 1998); there is no duration of the event and the order of the time is important.
- *Interval* [7]Time: events are measured on an interval scale. The level of accuracy and precision is defined by its granularity, the smallest time unit (e.g. second, hour, day, year) used in measuring time (Neumann 2005).

[6] A measurement scale in which numbers indicate rank (from highest to lowest). There is no zero point in the rank order, and the differences between the ranks do not need to be equal.

[7] A data scale that preserves the units used but does not have a natural zero point. Interval scales often result from the difference between two values using the same scale.



Ordinal time scale



Interval time scale

Visualisation of Time

Time cannot be seen and visualised directly, but only its effects such as the changes in the spatial and thematic dimensions. It is only natural, therefore, that temporal controls are usually tied to visualisation, serving both navigation and visualisation purposes. Depending on the topology, range and granularity of the time, linear, circular or tree representations and controls are more suitable. (Neumann 2005)

The different temporal navigation elements are presented in the next chapter.

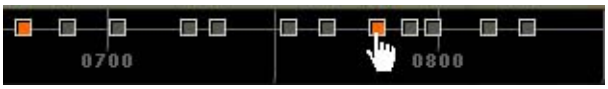
Temporal navigation is always combined with a theme. The question "What has happened when?" is the most important question in temporal navigation. Therefore, temporal navigation acts like thematic navigation but instead of the theme you select or define the time.

1.4.2. Temporal Navigation Elements

There exist several time controls and representations. The following table lists some of these controls divided into linear, circular and other controls (Neumann 2005). Click on the underlined text to see an example of the presented time control tool.

Linear Controls and Visualisation	Circular Controls and Visualisation	Other
Interactive Time Lines / Life Lines	**Knobs**	**Day / Night Buttons**
Temporal Slider	**Watches**	**Calendar Widgets**
Smart Scrollbars	**Wheels of Months or Seasons**	**Text Input**
Small Multiples along Time Line	**Cogwheel**	**Selection Lists** (e.g. List of months)

Interactive time lines are particularly useful since they can serve both visualisation and navigation. Time lines can be used to show events, processes and the distribution of attribute values along time. Processes or uncertainty can be visualised using gradients. Time lines can be combined with sliders and scrollbars. Small multiples are a series of small pictures representing the same topic over time. These can be ordered along a time line as it is shown in the following picture. (Neumann 2005)

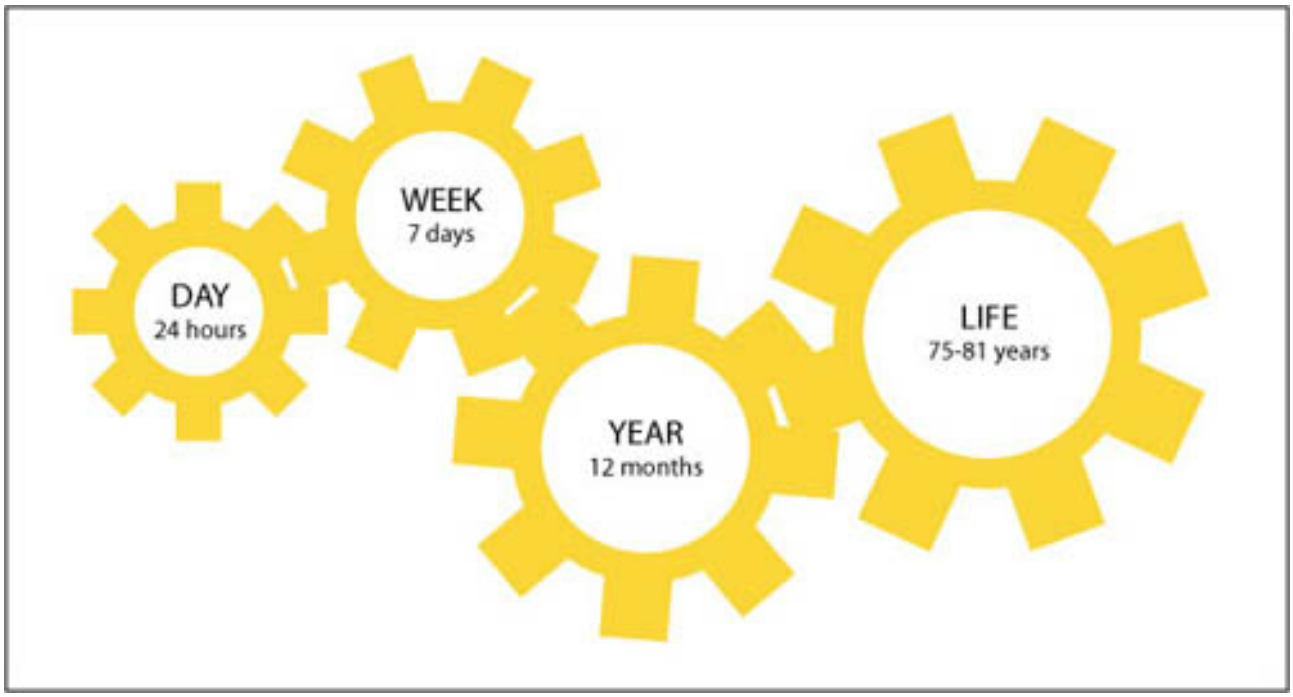


Timeline with small multiples (National Geographic)

The following example contains a time line which is combined with a slider. Clicking on the time line allows you to jump to the time that interests you.

Timeline combined with slider

An interesting option is to use cogwheels for controlling time. A series of cogwheels with different sizes and ordered by granularity can intertwine with each other and allow the user to navigate through time at various speeds. (Neumann 2005)



Cogwheels for Navigation and Representation of Time. According to (Drewe 2005)

1.4.3. Examples of Temporal Navigation in Web Pages

Temporal navigation in web pages are mostly used when the date and chronology of certain events are the most important facts. The following examples show you some possibilities how to realise temporal navigation in web pages.

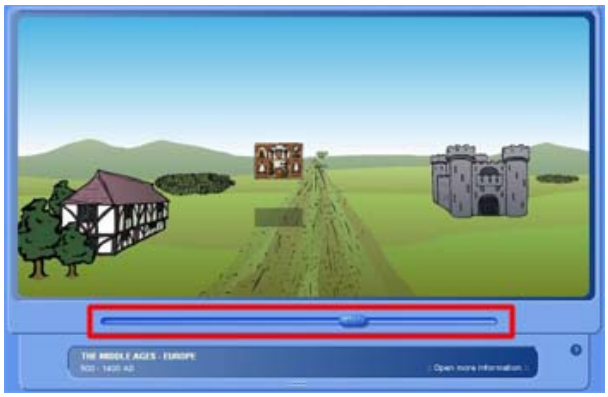
Archaeological Park

This web site includes a time line of the history of Jerusalem. The time line is used as a navigation element which places the in-depth information in its historical context.

History of Jerusalem (Archeological Park)

History of Medicine

This application shows an overview of the history of medicine. "*You can use the blue slider below the animation window to travel through the history of medicine. Roll your the mouse cursor over the objects that appear to show basic information. Click the objects for more information.*" (Schoolscience)



History of Medicine with Timeline (Schoolscience)

Time Wall

"*The TimeWall of the company Inxight displays time on a living three-dimensional "wall".*
It enables users to see patterns over long time horizons, while also being able to focus in on a particular time segment of interest. Filters allow users to narrow down information based on any combination of structured information, such as numeric, geographic, categoric or other criteria." (Inxight)
Unfortunately, we can show you only a screenshot of the application. Click on the image on the left-hand side to enlarge it.

Time Wall (Inxight)

9/11 Moment By Moment

"*The crash of American Airlines Flight 11 into the north tower of the World Trade Center on Sept. 11, 2001, shattered America's sense of security and set in motion series of events that continues to reverberate to this day.* " (MSNBC) The presented application contains a time schedule that lists the parties that are involved in those events and the time when they happened.
Explore the time schedule! Click on a time point, or navigate with the scroll bar below the time schedule, to follow the initial days of the crisis.

What happened when on September 11-14, 2001? (MSNBC)

1.4.4. Examples of Temporal Navigation in 2D Maps

Within thematic maps, time plays an important role. Imagine you would have to visualise the air pollution of Bern (Bern is the capital city of Switzerland): The first thought would certainly be "For which time period do we have to visualise the pollution (years, seasons, months, days, hours, minutes)?" Without these time specifications it would not make sense to produce an air pollution map.
Often, you have the possibility to animate the various themes that stand for a defined time chronologically. The animation allows you to observe the variation of a theme over a specific time span.
The following examples show interactive maps that feature temporal navigation.

Pearl Harbor

This multimedia presentation of the attack on Pearl Harbor contains a time line that is combined with small multiples. Click on the thumbnail below to start the multimedia presentation and then, in the new window that oppened, click on "Begin" to start the application. Explore the time line with the mouse.
Look what happens when you move the mouse cursor over the small squares between 0700 and 0900 o'clock and pay attention what happens to the clock that is down to the right.

Japanese Attack on Pearl Harbor (National Geographic)

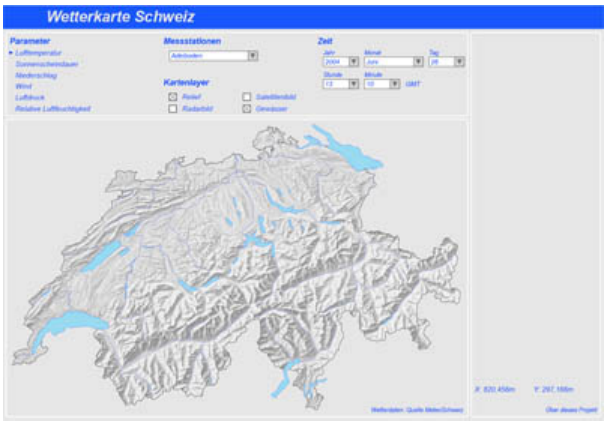
Replay of Bay Area Air Traffic

Within this application the air traffic of San Francisco and it's surroundings can be visualised and replayed. It includes specific information about flights from Oakland, San Francisco, San Jose International Airports as well as from smaller, general aviation airports in the area (Oakland International). You can choose between real time or historical information. "*Real time flights are delayed by 10 minutes. Noise data will be updated daily and may only be viewed during historical playback*" (Oakland International) . When selecting historical information you are able to define the exact date, hours and even minutes.
Explore the application! You have to click on the thumbnail to reach the application.

Air Traffic Application (Oakland International)

Weather Map of Switzerland

This application visualised all weather stations of Switzerland broken down by air temperature, duration of sunshine, precipitation, wind, air pressure, and relative atmospheric humidity. The point of time that was visualised could be defined with several selection lists (year, month, day, hour and minute).
Note, that we cannot provide the application anymore. Click on the thumbnail to enlarge the screenshot.



Weather Map Switzerland (Schmid 2005)

Adaption of Map Depending on Location, Time and Activity
The following example shows the opening and closing times of various features. The time dial changes the visibility of the features; each feature has an opening and a closing time and depending how long it will remain open it is shown or hidden. The opacity of the feature depends on the distance between the location of the red point and the feature; the closer the feature the less opaque. You can change the location of the red point in the map by dragging it.

1.4.5. Unit-Summary

Time defines our life and therefore it is also important in virtual environment.
There exist several time control and representation tools for multimedia applications. We distinguish between linear, circular and other control tools.

Linear Control Tools

- Interactive Time Lines / Like Lines
- Temporal Slider
- Smart Scrollbars
- Small Multiples along Time Line

Circular Control Tools

- Knobs
- Watches
- Wheels of Months or Seasons
- Cogwheel

Other Tools

- Day / Night Buttons
- Calendar Widgets
- Text Input
- Selection Lists

Temporal navigation is realised in both web pages and interactive 2D maps using these control tools.

1.5. Spatial Navigation

Learning Objectives

You will be able...

- ...to explain what zooming and panning is.
- ...to list at least three zooming tools, three panning tools and three spatial reference options.

Introduction

Spatial Navigation is part of our daily life. We navigate through the world with each step we do. Real objects such as buildings, trees, etc. serve to get our bearings.
Orientation problems arise whenever our surroundings have very few objects which can be used to get our bearings, for example on unknown terrain, in darkness, in the desert or at sea. To be able to orientate us in such terrains, different navigation techniques emerged.
A similar situation can be found in the virtual space. Because we do not have real objects that can be used to get our bearings, spatial navigation tools are necessary to solve our orientation problems.
In this unit, we introduce the realisation of spatial navigation in multimedia applications such as web pages and interactive 2D maps. Especially for interactive screen maps, spatial navigation is very important.

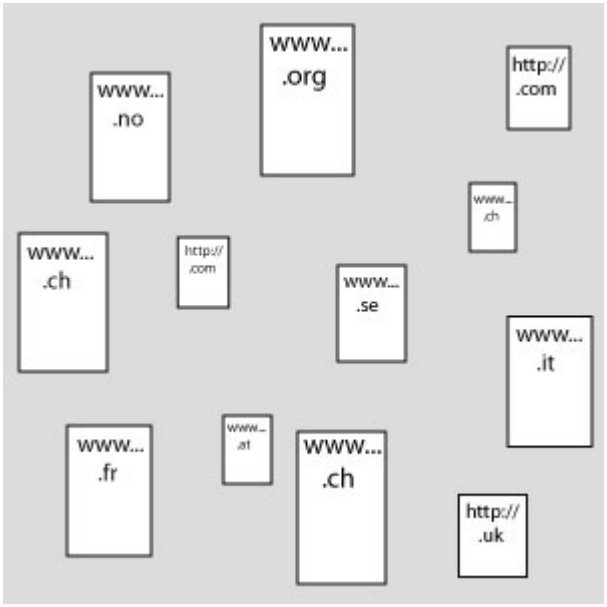
Example of Spatial Navigation

1.5.1. Spatial Navigation on the Internet

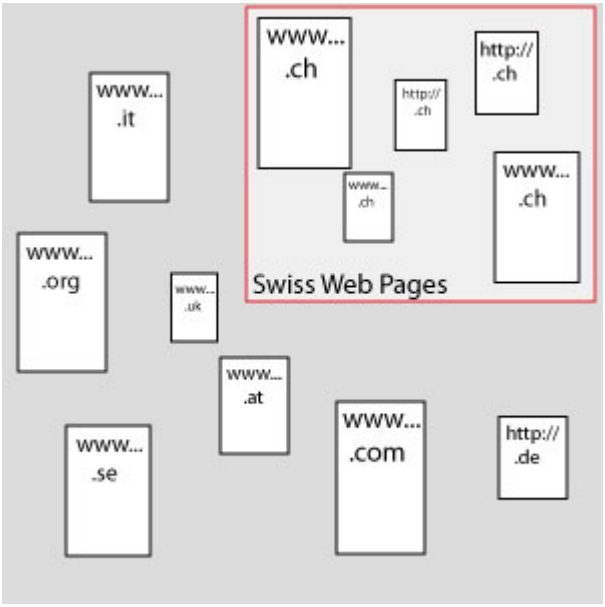
Spatial Navigation for the Internet is not really common, because the space on the Internet is only virtual and therefore not visible.
Spatial navigation on the Internet can be seen as follows:
All web pages together build the space. Imagine you use the Google search engine and type a word such as "spatial navigation" in the input bar. The search engine then looks for all files that are about this topic. When you additionally select the button "web pages from Switzerland", as it is shown in the image below, you will receive only the web pages from Switzerland that contain your terms.

Spatial Navigation on the Internet (Google)

We can say that you have zoomed to your preferred topic and to the virtual space of Swiss web pages. You can still zoom closer to the topic by typing in a more specific expression like "Spatial Navigation on the Internet". Even typing in the URL of a specific web page in the address bar of a browser is zooming. You then zoom very close to your topic.



All web pages together build the space



Zoom in means to look for a specific web page or topic

1.5.2. Spatial Navigation in 2D Maps

Spatial navigation is used in most interactive maps. Especially for address and route search systems it is substantial to feature spatial navigation because their main function is showing maps in different zoom levels.
The most common spatial navigation tools for 2D maps are:

- **Zooming**
  - enlarging or reducing a portion of a map or image to see it more clearly or to get a better overview
  - changing map scale

  You can zoom in and out by repositioning the slider knob.

- **Panning or Scrolling**
  - repositioning or re-centering the map on the screen

To be able to pan the map, you first have to zoom in a bit and then avtivate the pan button. Afterwards, you can reposition the map with drag and drop actions.

Panning and zooming are used to navigate through information spaces that are too large to be conveniently displayed within a single window (Cockburn et al. 2003)
According to (2005), these functionalities should be incorporated into dynamic maps because

1. It is common and widely understood
2. It potentially encourages exploration
3. It allows for greater information density than would be possible with static digital maps, and thus, helps to overcome the low resolution limitations of electronic displays
4. It allows users to scale and position the map to suit their needs

Navigation Tools
There is no single best (one-size-fits-all) spatial navigation tool that fits all needs. The suitability of navigation tools depends on the user (experience, motivation), the task to solve and the type and size of information space. Larger information spaces probably need different tools than smaller ones. Good mapping systems therefore provide multiple methods for zooming and panning. (Harrower et al. 2005)

1.5.3. Zooming

There exist several zoom options that can be implemented in an interactive map. We here present you some of them:

- **Plus / Minus Buttons**
  Zoom Buttons are available that allow to zoom in the map.

- **Slider**
  A slider allows to select an arbitrary zoom step by moving the slider bar.

- **Predefined Zoom Steps and Full view buttons**
  This method allows on the one hand to zoom the map to the predefined zoom steps and on the other hand to reset the current map extent to the original map extent.

- **Dragging a rectangle in the main map**
  This method allows the user to draw a box directly on the map that becomes the new extent of the map.

- **Specify Explicit Coordinates or Scale / Zoom to selection**
  Today, some online map search tools include the input of a street address, geographic coordinates, specific scale, map dimensions, or center-and-zoom on a landmark or pre-defined location.
  An example is the Map24 search engine. You can type in an address or route and the map will directly be zoomed to this location. Try it out on the **Map24 web site**.

Many online mapping systems feature pre-defined zoom controls. These systems therefore constrain the user to predefined map scales. These pre-defined scales are justified for applications whose levels of detail change with each pre-defined zoom level. For details see chapter **Adaptive Zooming** of lesson "Design for Screen Maps".

For maps without *adaptive zooming* [8], these pre-defined scales may not be what the user wants, and the user may discover this only after trying many of the scale options (Harrower et al. 2005). Therefore, it is not recommended to predefine the scales of a map without adaptive zooming. For such maps, it is better to implement a slider with which an arbitrary zoom scale can be selected.

You may have recognised that exploring a map by only being able to use zoom functions is not that satisfying because when e.g. having only zoom in and out buttons, you cannot define by yourself the region that will be zoomed to. That is why, most of the time, zooming and panning are made available together.

1.5.4. Panning

To be able to pan the map, you first have to zoom in a bit. Afterwards you can use the specific pan options.

- **Pan Hand**
  The entire map can be used to pan. Ideally, the system should provide obvious visual cues such as a hand icon that closes to indicate "grab". Because there is no scale relationship between panning and the map, high mouse mileage has to be done.

- **Separate Pan Buttons**
  Pan buttons restrict the panning choices to either 4 or 8 directions, although they appear to be an easily understood interface widget.

[8] A zooming is called adaptive when the representation of a screen map is adapted to the zoom level. Therefore for each zoom level, the quality of the map is always high and the cartographic principles are conformed. Hence, adaptive zooming describes the adjustment of a map, its contents and the symbolization to target scale in consequence of a zooming operation (=scale change).

- **Sensitive Areas at the Map Borders**
  Sensitive areas at the map borders restrict the panning choices to 4 directions.

- **Panning with Reference Map**
  The reference map employs a global thumbnail of the entire document space and a directly manipulable box to indicate the portion of the image displayed in the main window. With this zoom box, the user can zoom and pan to exactly the scale and location they wish. Grabbing this box allows the user to traverse the entire document in only a few pixels of mouse movement.
  The appeal of this reference map is that they are both an orientation device and an interactive widget.

- **Recentering with a Mouse-Click**
  The content of the map window can be changed by one mouse click. The actual position of the mouse cursor (when clicking) builds the center of the new map extent.

- **Panning with Keyboard (arrow keys or specified shortcuts)**

Often seen as an "expert" option, keyboard shortcuts can be significantly faster than *GUI* [9] browsing options. Be aware that novices might not discover this non-obvious functionality and that keyboards usually restrict panning to four directions (arrow keys) or eight directions (number pad).

- **Smart Scrollbars**
  Smart Scroll Bars appear only when needed, and they provide local-global orientation cues because their length dynamically changes to indicate what proportion of the entire document is current visible.
- **Rate-Based Scrolling**
  This approach allows for panning by keeping the mouse always centered on the screen. If the user moves the mouse left, the scene pans left. The faster the user moves the mouse, the faster the screen pans underneath.

Many mapping systems feature pre-defined pan controls: The map jumps e.g. 25% of its width per panning request on the interactive direction indicators (which further constrain the user to only four or eight directions). Having to traverse a large distance using such tools is slow and potentially makes it impossible for the user to browse exactly the amount desired (Harrower et al. 2005). According to (2005) the best map panning controls allow both user-defined browsing and pre-defined browsing.

1.5.5. Spatial Reference Options

- **Coordinates on Mouse-Move**
  The coordinates of the mouse cursor are shown when moving the mouse over the map. Try it out in the next example.

- **Linked Reference Map to Provide Overview**
  The reference map employs a global thumbnail of the entire document space and a box to indicate the portion of the image displayed in the main window.

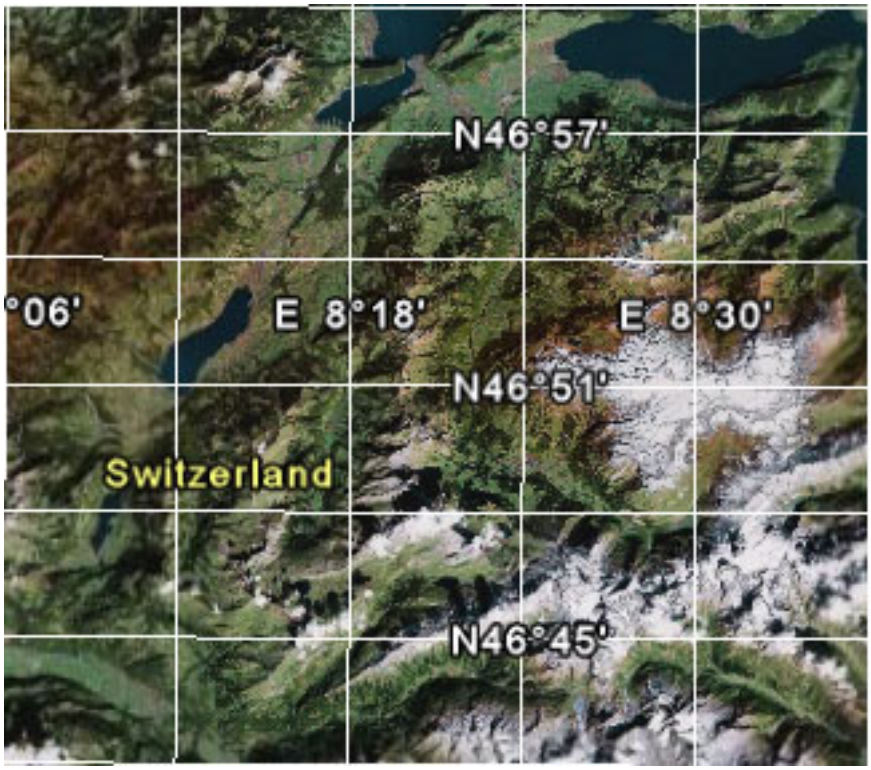
[9] The use of pictures rather than just words to represent the input and output of a program. A program with a GUI runs under some windowing system (e.g. The X Window System, Microsoft Windows, Acorn RISC OS, NEXTSTEP). The program displays certain icons, buttons, dialogue boxes etc. in its windows 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.

- **Map-Extent Lines / Arrows Indicating Map Width and Height**
  Map-Extent lines or arrows indicate the actual map width and height.

- **Scale-Bar**
  An interactive scale bar shows the dimensions of the actual extent.

- **Grid Lines**
  Google Earth is an application that has implemented grid lines. Since the application has to be downloaded and installed on the computer, we only show you two screenshots. If you have the rights to install applications on your computer, visit the **Google Earth Website**, download and install the application and explore the grid lines by yourself. You have to activate the grid lines under "View -> Lat/Lon Grid".

Activating Grid Lines in Google Earth (Google Earth)



Grid Lines in Google Earth (Google Earth)

- **"Rocket Functionality" - quick zoom out and back to original extent**
  If you are zoomed in very close in a map, you easily lose your orientation because you cannot see the surroundings anymore. This method allows to get a quick overview of the question "Where am I?". Try it out on the **Map24 Website**. Type in your address and use the "Rocket Functionality".

Rocket Functionality in Map24 (Map24)

1.5.6. Self Assessment

Search the internet for three interactive maps with various zoom, pan and spatial reference functions. Send the links to these maps to your tutor by e-mail. Your tutor will collect all the links, pick some of the most interesting maps and post the links to these maps on the discussion board "Spatial Navigation". Then, you will have to look at these maps carefully. Write a short essay (ca. 1/2 A4 page) about the map's spatial navigation tools. First, define for each map your use of the map and then answer to questions like "Do you miss a tool?" or "Do you think that one or several tools are unnecessarily implemented?". Give reasons for your opinion. Hand in the essay to your tutor.

1.5.7. Unit-Summary

Spatial Navigation on the Internet

Spatial Navigation for the Internet is not really common, because the space is only virtual and therefore not visible. The entire Internet must be seen as space which consists of all web applications together. Navigating through the web sites can be seen as spatial navigation.

Spatial Navigation in 2D Maps

Spatial navigation, whose most common tools are zooming and panning, is mainly used in interactive maps.

There exist many possibilities how to realise zooming and panning functions.

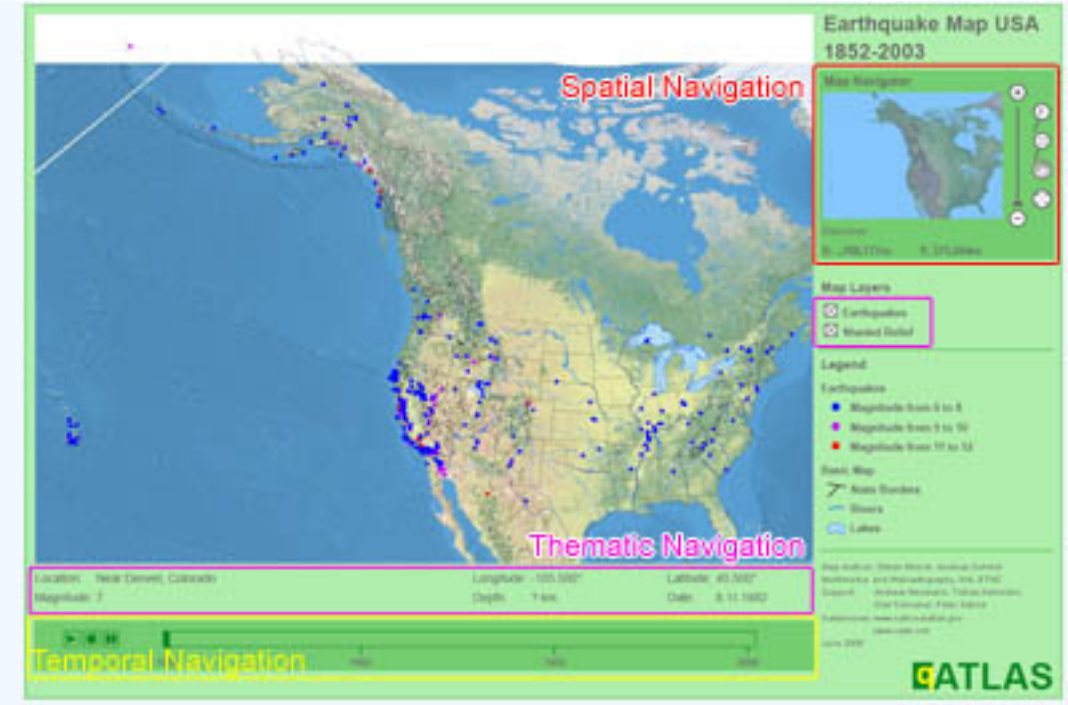
Panning and zooming controls are employed in nearly all interactive mapping systems and have become "second nature" to those who use computer regularly. Their ubiquitous nature is due to our daily need to visualise large information spaces through small computer windows. (Harrower et al. 2005)

Besides zooming and panning controls, it is recommended to implement spatial reference options in 2D maps, because they provide information about the spatial reference. Possible tools are: coordinates on mouse-move, reference map, scale-bar, grid lines, etc.

According to (2005), good map navigation tools should provide users with strong local-global orientation cues to reinforce a sense of place, prevent frustration, and potentially increase efficiency of use.

1.6. Self Assessment

Search an arbitrary multimedia application on the Internet. Explore and study the application. Determine the navigation tools for thematic, temporal and spatial navigation. Make a screenshot of the application (if it is a web page with several files, make a screenshot of the first page). Define three different colours which stand for the three navigation types and mark the navigation tools for each navigation type with rectangles coloured with these colours. A possible solution shows the image below



Possible Solution

Put the screenshot and the address to the application on the discussion board "Navigation Types". Pick one of the applications of your colleagues and test the application for the navigation tools of the three navigation types. Did your colleague forget to mark one tool? Do you find more tools than your colleague? Did your colleague assigned the right navigation type to the tools? Do you agree with your colleague's decision? Comment on these questions on the discussion board.

1.7. Summary

Have a look at the following movie. The last sheep has definitely no sense of orientation and perhaps never heard the word "navigation" (Click on the thumbanil to watch the movie!).

Sheep without orientation (Holy Lemon)

Navigation provide answers to questions like:

- Where am I?
- Where can I go?
- How will I get there?
- How can I get back to where I once was?

We normally navigate through the world with our eyes, but sometimes one cannot use his eyes because of various reasons: one might be blind or might be in the dark, etc. Being blind or being in the dark means that we have to use other senses than the eyes to navigate, such as the ears, touch or even smell.
Within multimedia applications we need navigation as well. Multimedia navigation enables to explore information spaces that are too large to be conveniently displayed in a single window. We mainly navigate with our eyes and we cannot rely on sensory perception such as touch or smell. In addition, you have not the same objects as in real space which can be used to get your bearings. Therefore we need navigation tools which guide the user through the information space of a product or web page, helping explore the content and functionalities of a project.
There exist a few principles good navigation tools should follow:
They are intuitive and do not force the user to first study extensive manuals or help documents; they are consistent throughout the whole product: this includes the appearance (e.g. Colours and fonts), the placement and the functionality of the tools; etc.
We distinguish between three navigation types: spatial, temporal and thematic navigation.

- **Thematic Navigation**
  Thematic navigation controls the thematic information of a multimedia application. In web pages this is normally the navigation between different files. In interactive 2D maps, thematic navigation often allows to change the appearing of the map or to extract thematic attributes or values out of the map.
- **Temporal Navigation**
  Some multimedia applications contain a temporal component. In each time span (minutes, hours, days, etc.) happened specific events that are visualised in the application. Navigating between these events is temporal navigation.
- **Spatial Navigation**
  Spatial navigation is the process of orienting and moving through a virtual environment (University of Edinburgh). Spatial navigation is mainly used in interactive 2D maps.

There are several possibilities how to implement these navigation types in multimedia applications. In this lesson we only have looked at web pages and interactive 2D maps. While spatial navigation is only realised in interactive 2D maps, we find thematic and temporal navigation in both application types.
Thematic navigation is subdivided into two structures:

- Sequential

- Non-Sequential

For web pages, the non-sequential navigation structure can be further subdivided into two types:

- Hierarchic Data Structures
- Network Data Structures

Temporal navigation is used in applications where time plays an important role. Time is always combined with a theme. The question "What has happened when?" is the most important question in temporal navigation. Therefore, temporal navigation acts like thematic navigation but instead of the theme you select or define the time.
Spatial navigation is mainly used in interactive 2D maps. Panning and zooming controls are employed in nearly all interactive mapping systems and have become "second nature" to those who use computer regularly. Their ubiquitous nature is due to our daily need to visualise large information spaces through small computer windows. (Harrower et al. 2005)

1.8. Glossary

Adaptive Zooming:

A zooming is called adaptive when the representation of a screen map is adapted to the zoom level. Therefore for each zoom level, the quality of the map is always high and the cartographic principles are conformed. Hence, adaptive zooming describes the adjustment of a map, its contents and the symbolization to target scale in consequence of a zooming operation (=scale change). (Brühlmeier 2000)

File-Browser:

A file browser is a computer program that provides a user interface to work with file systems. They are very useful for speeding up interaction with files. The most common operations on files are create, open, edit, view, print, play, rename, move, copy, delete, attributes, properties, search/find, and permissions (Wikipedia).

Fuzzy Navigation:

Fuzzy navigation is when one wants to explore an application without any specific target.

GPS:

"*Global Positioning System, based on data transmitted from a constellation of 24 satellites. At least 4 sattelites have to be in range for correct positioning by measuring the signal runtime from the sattelites to the device.*" (Neun 2006)

GUI (Graphical User Interface):

"*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)

Hypertext:

Hypertext is text which is extended by links. These links act as pointers to other pieces of text that are located elsewhere, either in the same document or in another document or both. Using these links enables users to "browse around" in one or more documents.

Interval Scale:

"*A data scale that preserves the units used but does not have a natural zero point. Interval scales often result from the difference between two values using the same scale.*" (Bertoline et al. 2002)

Log:

"*A log is a device used in navigation to measure the speed of a ship.*" (Wikipedia)

Multimedia Navigation:

Navigation can be described as the task of determining position within the information space and finding the course to the envisaged information and other relevant related information. Navigation helps to explore information spaces that are too large to be conveniently displayed in a single window. The information space consists of spatial, temporal and thematic dimensions. Therefore, one distinguishes between spatial, temporal and thematic navigation. (Neumann 2005)

Navigation:

The word navigation is originally a seafaring term. Navigation describes the process of estimating one's present position based on various tools. In earlier times wind, tide and currents acted as navigation instruments and today there are maps, magnetic compasses and even satellite-guided GPS systems that are used as navigation instruments.

Ordinal Scale:

A measurement scale in which numbers indicate rank (from highest to lowest). There is no zero point in the rank order, and the differences between the ranks do not need to be equal.

Pan:

With panning you can reposition or re-center an information space such as a map on the screen.

Precise Navigation:

Precise navigation is when one exactly knows what information is to be extracted out of an application. The corresponding tools let the user quickly go to the location he/she is looking for.

Radar:

"*Radar is a system that uses radio waves to detect, determine the distance or speed of objects such as aircraft, ships, rain and maps them.*" (Wikipedia)

Space Perception:

"*Process through which humans and other organisms become aware of the relative positions of their own bodies and objects around them. Space perception provides cues, such as depth and distance, that are important for movement and orientation to the environment.*" (Encyclopedia Britannica)

Spatial Navigation:

Spatial navigation is the process of orienting and moving through a virtual environment (University of Edinburgh). Spatial navigation is mainly used in interactive 2D maps as you will see in further chapters

Temporal Navigation:

Some multimedia applications contain a temporal component. In each time span (minutes, hours, days, etc.) happened specific events that are visualised in the application. Navigating between these events is temporal navigation.

Thematic Navigation:

Thematic navigation controls the thematic information of a multimedia application. In web pages this is normally the navigation between different files. In interactive 2D maps, thematic navigation often allows to change the appearing of the map or to extract thematic attributes or values out of the map.

Typography:

Typography is the art and technique of selecting and arranging type styles, point sizes, line lengths, line leading, character spacing, and word spacing for typeset applications. These applications can be physical or digital. (Wikipedia)

User Profile:

User profiles are brief studies of the sort of person who might visit your application (Fleming 1998).

Zoom:

With zooming you can enlarge or reduce a portion of a information space (e.g. map or image) to see it more clearly or to get a better overview.

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