Computer Cartograhy and Cartographic Knowledge

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The problem

Past: production of graphics/maps is a business of professional designers and cartographers

Now:

- Wide spreading of statistical graphics and GIS software
- Appearance of visualization and mapping services in the Internet

⇒ It is necessary to incorporate required expertise into graphics software

History of Intelligent Visualization Design

- 1967 J.Bertin – Theory of Visual variables
- 1986 J.Mackinlay – Implementation: using visual primitives, composition rules, and primitive tasks
- 1995 V.Jung – Application to map design, taking into account primitive tasks

All consider paper-like, static graphics for communication purposes

We are focused of dynamic, interactive graphics for visual data exploration

Descartes -> CommonGIS (Problem Definition)

Support exploratory data analysis and decision making by interactive maps and other visualization-based techniques

1. Bertin's theory of visual variables
2. Semantics of data
3. Interactivity of graphics
4. User's analytical task

Intelligent Visualization Design (1)

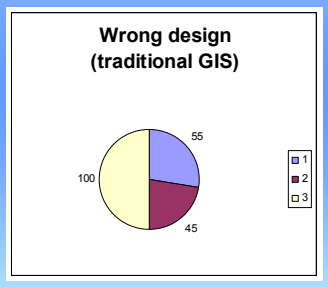
Visual variables

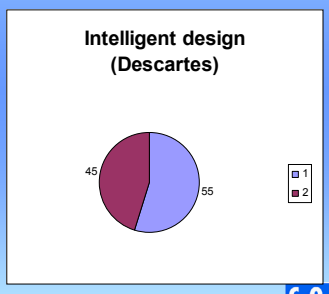
Level of perception	Size	Value	Color	Shape
quantitative	⊕			
ordered	⊕	⊕		
selective	⊕	⊕	⊕	
associative			⊕	⊕

Intelligent Visualization Design (2)

Data semantics !!!

Female	Male	Total
55	45	100





Intelligent Visualization Design (3)

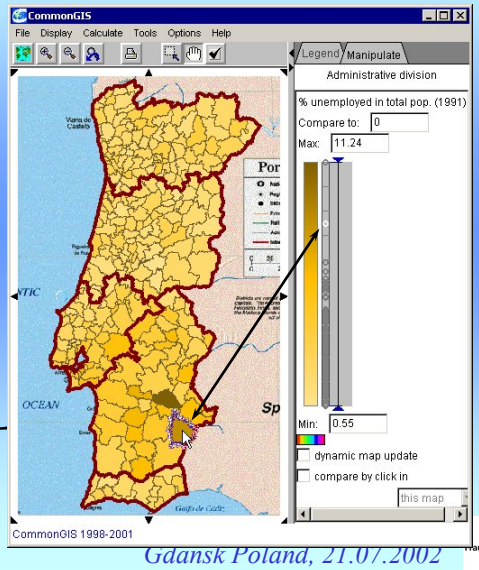
Interactivity !!!

Example 1: a Choropleth Map (1)

	read values	find values	compare values	detect trend
Bar charts	certainly good	good	good	bad
Pie charts	average	certainly bad	good	bad
Choropleth maps / Intensity	bad	slightly good	certainly bad	good
Choropleth maps / hatching	average	slightly good	terrible	average

(Source: Doctoral Thesis, Volker Jung, p. 168)

A Choropleth Map (2)

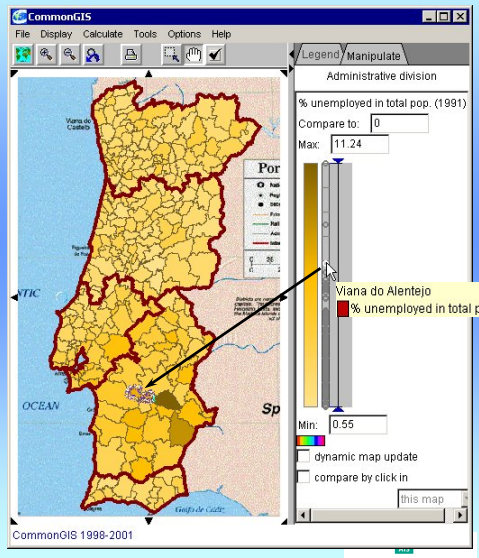


big values

How far are these values from the rest?

A Choropleth Map (3)

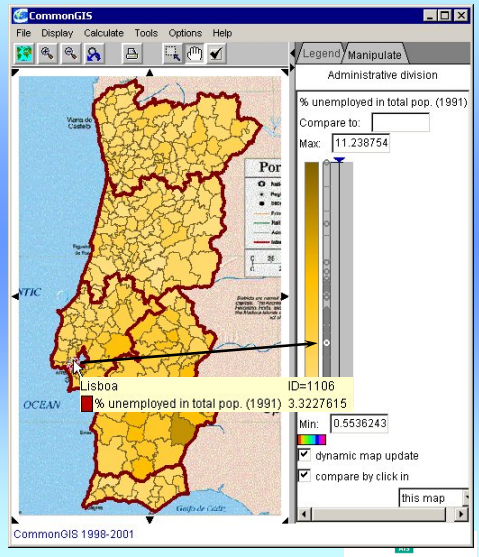
Where on the map is the next largest value?



Gdansk Poland, 21.07.2002

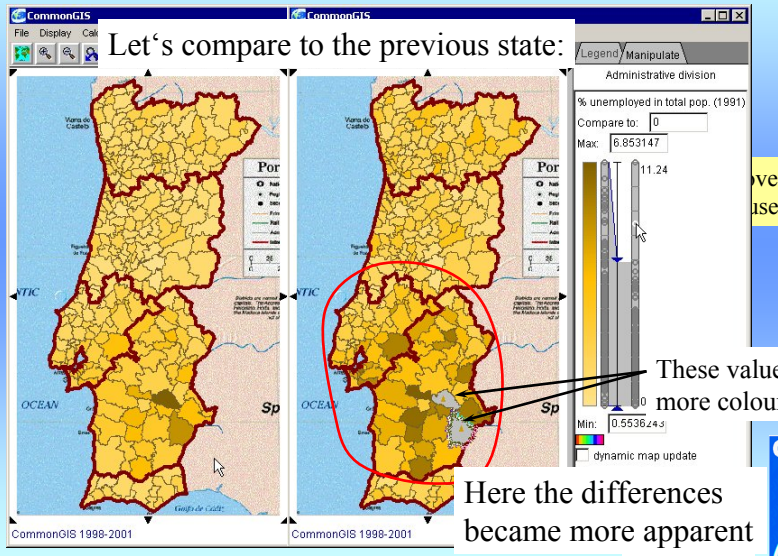
A Choropleth Map (4)

What is the relative position of Lisboa among others?



Gdansk Poland, 21.07.2002

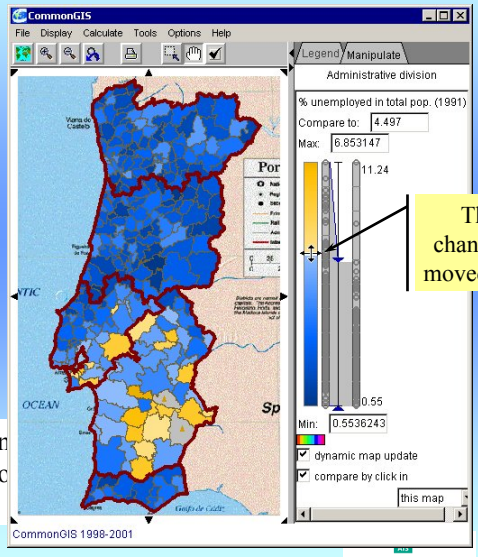
A Choropleth Map (5)



11 *Gdansk Poland, 21.07.2002*

A Choropleth Map (6)

Is there any spatial pattern or trend?



Here the unemployn rate is higher, but cc we see more?

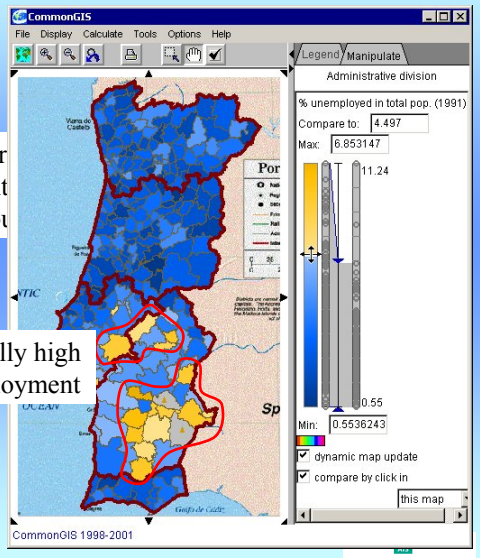
12 *Gdansk Poland, 21.07.2002*

A Choropleth Map (7)

A closer look...

spots of higher unemployment in the neighbou

especially high unemployment



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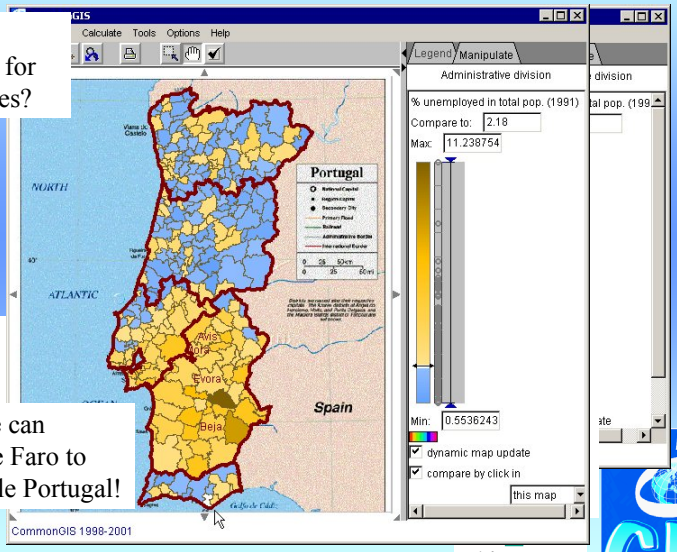
A Choropleth Map (8)

Can we use a choropleth map for comparing values?

Now we can compare Faro to the whole Portugal!



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Interactive Choropleth Map (Conclusion)

Our starting point:

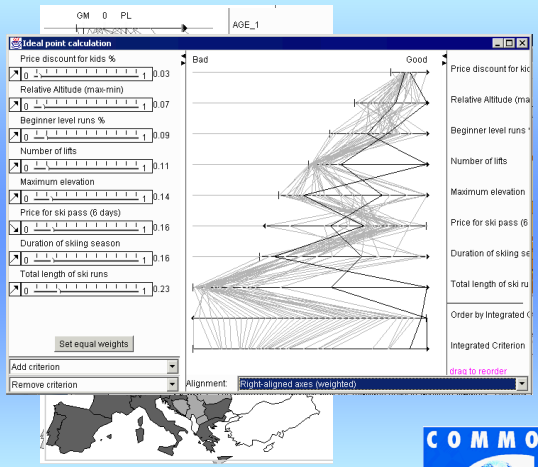
	read values	find values	compare values	detect trend
Bar charts	certainly good	good	good	bad
Pie charts	average	certainly bad	good	bad
Choropleth maps / Intensity	bad	slightly good	certainly bad	good
Choropleth maps / hatching	average	slightly good	terrible	average

We successfully used an interactive choropleth map for
- reading values
- finding values
- comparing values (pairwise and one-to-many)

In addition:
- we could make spatial trends and patterns better visible
- we could investigate patterns more in detail

Parallel Coordinates Plot: adaptation for problem solving

Possible usage (see Smart Graphics 2001):
- Comparison of absolute values
- Study of statistical distribution of values
- Find objects with similar values, compare objects
- Classify objects by similarity
- Evaluate objects by multiple criteria



Pie charts ?

Demo:

Example of data exploration with interactive pie-charts

An Example of Tool Design: Data Analysis

- Given: time-series demographic data referring to areas of territory division (e.g. municipalities of Italy)
- Spatial objects (countries) can be regarded as stable in time, i.e. do not change their size, shape, or location, and do not disappear
- Changing are attribute values associated with the objects

An Example of Tool Design: Task Analysis

What questions about the data (analytical tasks) can potentially arise?

"Local" tasks:

- What is the value of the attribute at moment t in area a?
- How does the value in a_1 differ from that in a_2 at moment t ?
- How did the value in area a change from t_1 to t_2?
- How does the change in a_1 from t_1 to t_2 differ from that in a_2?
- What is the trend of value change in a over interval $[t_1,t_2]$?
- How does the trend in a_1 over interval $[t_1,t_2]$ differ from that in a_2?

"Global" tasks:

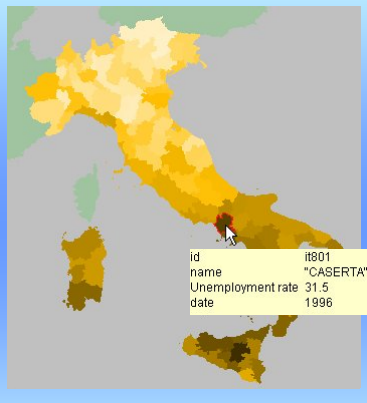
- What was the spatial pattern at moment t?
- How did the pattern change from t_1 to t_2?
- How are the changes from t_1 to t_2 distributed over the territory?
- What is the trend of pattern change over interval $[t_1,t_2]$?
- How do the "local" trends vary over the territory?

An Example of Tool Design: Technique Selection

• See the spatial pattern at a moment: choropleth map

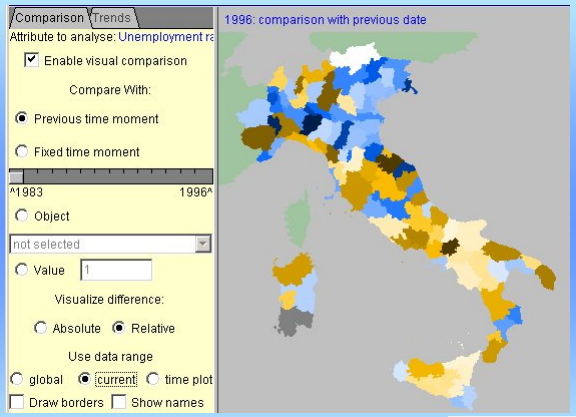
• See changes in the spatial pattern: choropleth map animation

• See values in areas: interaction with the map (mouse pointing)



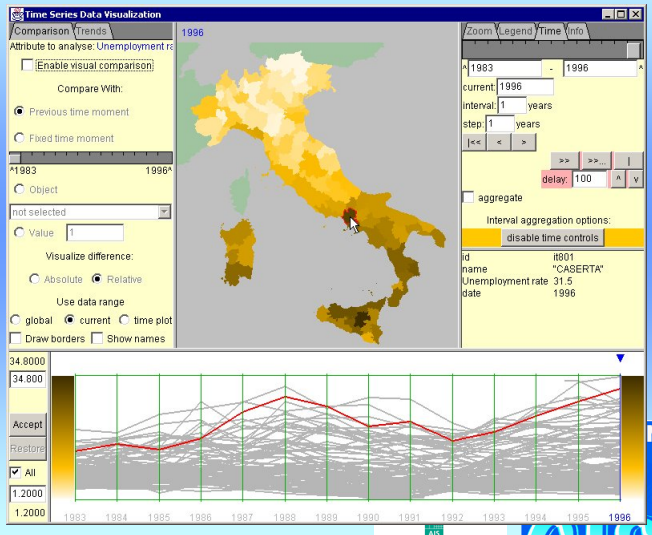
An Example of Tool Design: Technique Selection (contd.)

• See changes at particular locations + spatial distribution of changes: change map



An Example of Tool Design: Technique Selection (contd.)

• See local trends, compare trends: time-series plot



… and so on

Task Analysis Problem

What questions about the data (analytical tasks) can potentially arise?

"Local" tasks:

- What is the value of the attribute at moment *t* in area *a*?
- H
- How did the value in area *a* change from
- How does t
- What is the trend of value change in *a* over interval [t_1,t_2]?
- How does the trend in a_1 over interval [t_1,t_2] differ from that in a_2?

"Global" tasks:

- What was the spatial pattern at moment *t*?
- from t_1 to t_2?
- How are the changes from t_1 to r the territory?
- What is the trend of pattern change over interval [t_1,t_2]?
- How do the "local" trends vary over the territory?

Have all potential tasks been enumerated?

⇓

We need a task typology!!!

Known Typologies

"There are as many types of questions as components in the information"

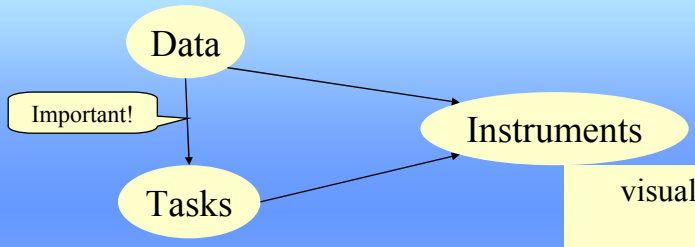
J.Bertin

But…

- Where are such tasks as "compare" and "relate"?
- Is there a principal difference between the intermediate and overall levels?
- Is the concept of reading levels applicable to every data component (e.g. attributes)?

Good: task types expressed in terms of data components (not too abstract)

What a Tool Designer Eventually Needs



visual variables
+
interaction techniques
animation
computations (e.g. change map)
…

… a theory (methodology) supporting selection of instruments depending on data characteristics and anticipated users' tasks

(like Bertin's theory for visual variables)

Usability tests of CommonGIS

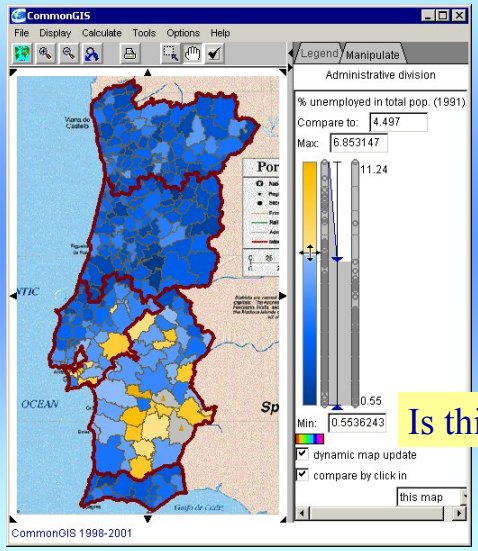
Goal:

Make our tools accessible and usable by a wide community of users

✓ accessibility: the tools are available in the Web and can run inside a standard Java-enabled browser

o usability: ? ? ?

The Usability Problem



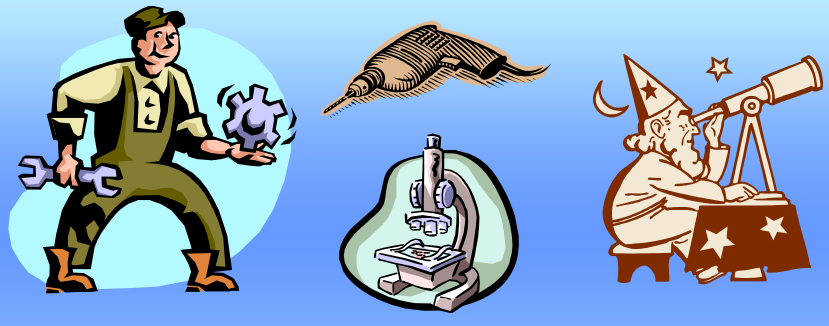
Opinion of the participants in the first usability studies in the CommonGIS project:

- the interactive tools are only for very advanced users

⇒ they should be hidden to avoid confusing „normal“ people

Is this a problem of UI?

What Is an Intuitive UI?



Which of the things is more „intuitive“?

It makes sense to talk about an intuitive UI when the user is expected to know the function of the thing or at least to guess it (by analogy with similar things)

⇒ When the function is new, the user has to be taught

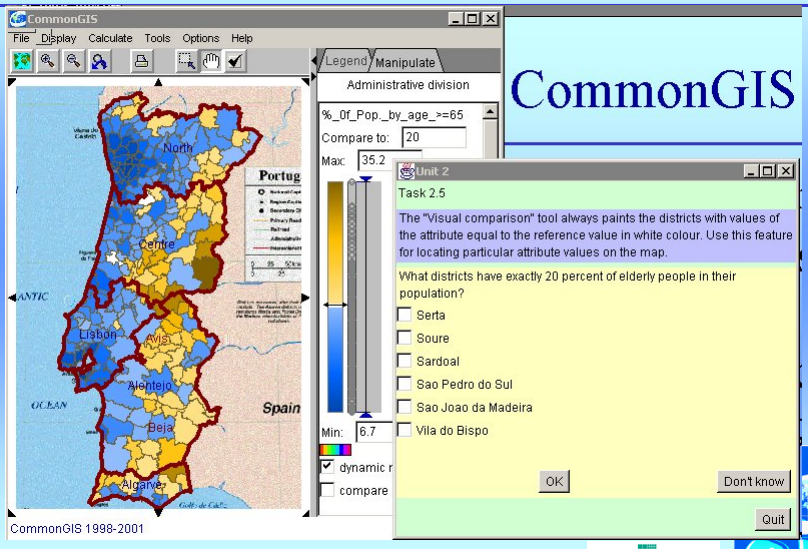
The Second CommonGIS Usability Study

- Prior to the tests the subjects were given a live demo (~ 30 min.)
- The subjects were asked to fulfil various tasks and answer questions, in contrast to the „free“ exploration of the system in the first experiment

⇒ The participants had to use the tools rather than just to view or play

⇒They concentrated on the utilitarian aspect of the tools rather than on their unusualness

An Example of a Test Task



Results of the Studies

Interactive tool	Total number of questions		Relative number of errors (% to the total number of answers)	
	1st round	2nd round*	1st round	2nd round*
Outlier removal (focuser)	12	6	9.25%	2.78%
Visual comparison (choropleth map)	15	10	8.89%	1.67%
Dynamic classification	16	8	**12.50%**	**8.33%**
Dynamic query	13	9	**28.20%**	**12.96%**
Dynamic link map ↔ scatter plot	15	11	8.89%	0%
Total	71	44	13.30%	4.92%

* The 2nd round took place 1 month after the 1st round. The same people participated in the 1st and the 2nd rounds. The purpose was to test if the users are able to preserve their skills in operating the tools.

Results of the Studies (Conclusion)

- ✓Objective result: the subject were rather successful in fulfilling the tasks by using the interactive tools.
- ✓Subjective result: the subjects liked the system and found it „fun to use“. Some participants were willing to use the system in their work.
- ⇒The studies confirmed the importance of teaching.

How to Teach the Users?

Options:

- Lecture/demonstration
  - Works well, but not always possible
- Printed manual
- On-line help
- Wizards
- On-line tutorials

How to Teach the Users?

Options:	Problems:
• Printed manual	People generally tend to avoid reading instructions
• On-line help • Wizards	Before looking for explanation in the help or launching a wizard, one must already know what function he/she needs
• Tutorials	People have to invest their time and efforts before actual use of the tools for their own purposes. ⇒ They would do this only being strictly sure that it is worthwhile.

⇒ It would be good to teach the users by assisting them when they do their own analyses and decision making

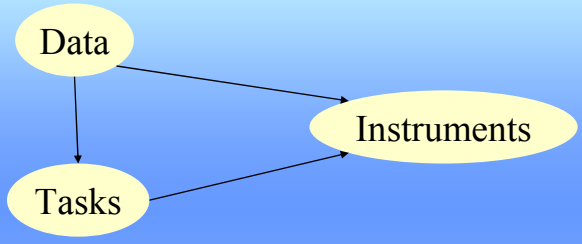
Intelligent User Guidance

Functions of the guide:

- Suggest appropriate tools according to the current user‘s task
- Instruct about the use of the tools in the context of this task
- Help the user in launching the tools

⇒ The guide needs to know the user‘s task

What Is Needed for User Guidance?



… a theory (methodology)
supporting selection of instruments
depending on data characteristics
and user’s tasks

How to Determine the User's Task?

- Guess 
- Ask the user

... is only possible after the user has made some relevant operation(s)

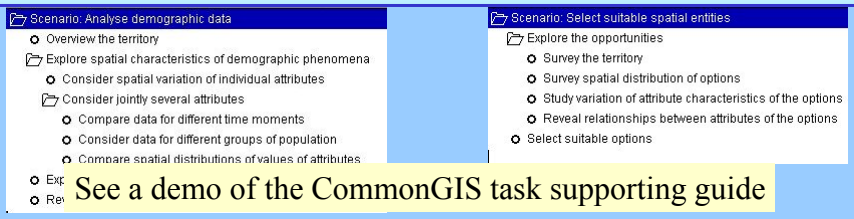
... but not too often!

– In data analysis or decision making the user performs lots of tasks.

+ These tasks are interrelated rather than independent. They usually emerge in a logical sequence.

✓ This feature can be utilised.

General Scenarios



- The user indicates which scenario corresponds better to his/her goals.
- The scenario contains a list (hierarchy) of potentially relevant tasks.
- The user selects tasks from the list, and the guide assists in fulfilling them.
- The task list 1) allows the user to indicate the current task; 2) serves as a reminder for the user.

Conclusion

- Interactivity changes properties of maps
- Tasks are important
  - for tool design
  - for user instruction and guidance
- Task typology is badly needed
- People should be taught to use new visualisation techniques
- The prototype guide needs to be extended, improved, and tested

Software

- Implementation: Java 1.1 compatible
  - Standalone application
  - Web applet
- The system is free for educational and research purposes
- Downloads at http://www.CommonGIS.de