spatialization
mapping non-spatial data
has not everything been mapped yet?

probably not, but...

have we gained new knowledge?
exploration
then...

to navigate the world seas.

carta portolana (1300–1500)
- where: ports
- how: wind direction (rhumb lines)

sea port-direction topology
exploration now...
to navigate the data seas.

cybermaps (~1970’s)
- where: data ports
- how: connections

data port–connection topology
information visualization

- images as external aids to amplify cognition

- scientific visualization / geovisualization (~1987)
  - of data from the physical environment
  - visible/invisible phenomena: terrain, air, water, people
    - interactivity: exploratory data analysis (numerical data)

- information visualization (~1989)
  - of data from the human environment
    - cognitive artifacts
    - interactivity
infoviz themes

• dealing with the information overload problem
  - information space always multidimensional
  - cognizable space is 3/4 dimensional
  - graphics as cognitive aids for knowledge discovery (EDA)

• data and space transformations (cartography!)
  - raw data ➔ data table ➔ visual structures

• direct data manipulation through graphical user interfaces

• non-geographical spaces as visual structure
  - metric space (spherical, cartesian grid)
  - topological space (node-link networks, trees)
a space is a space is a space...

are a coffee cup and a donut the same?

it depends!

...on morphology, cognition, topology etc.
space transformations...

- metric space \( \rightarrow \) cognitive space \( \rightarrow \) topological space
  - physical space shapes navigational space

(see also Hillier, 1996)
information space properties

preservation of meaning through abstraction

• **semantic generalization**
  - source domain ontologies
    • geographic primitives: point, line, areal features
    • formalized spatial structure: space types, scale continuum

graphic representation of meaning

• **semiotic generalization**
  - target domain mappings
    • semantic primitives: entities, trajectories, aggregates
    • formalized symbology: sign-vehicles
map making and visualization

spatialization framework

maker / user

source domain

target domain

sign-vehicle

metaphorical mapping

affordances

referent

interpretant

axis of representation

axis of communication

(after Pierce, 1954, Mitchell, 1990)
example: cyberspace

- cyberspace - “a common mental geography” (Benedikt 1991: 2)

- how do we map it?
  - various examples at the atlas of cyberspaces (Dodge, 2000)

- the good, the bad, the ugly
  - where is the killer map?
  - lack of sound design framework

- few formalization attempts
  - where are the cartographers?
typology of cybermaps

g√ cartography: map functions and types

1. maps of the net

• physical architecture (the world of bytes and wires)
  – spatial: where is cyberspace, who controls it?
  – data networks: time & distance matter

  – examples: Atlas of Cyberspaces (Dodge, 2001)
the Net yesterday and today

(1969)
map making and visualization

• architecture, services

(Eick, Bell labs)

(Dodge, CASA)

Art&Com

(Alcatel SA)

(Dodge, CASA)
usage

- participants

map making and visualization

WebTraffic Project, Harvard
typology of cyber maps (cont.)

2. maps on the net

• information architecture (the world of knowledge)
• semantic: what is cyberspace?
  – semantic networks: time & proximity matter
    (e.g. similarity, access)
spatialization. The extraction of information from large data sources is becoming more and more difficult. As the digital data flow rises exponentially, the need for techniques and methods to e...
typology of cybermaps (cont.)

3. maps for the net

- interfaces *(to)* the world of knowledge
- social: *how* can I access cyberspace, and *who* is also there?
  - collaborative network: time and metaphors matter
access & exchange

- knowledge

(Snowdon, U Nottingham, UK)

(Fabrikant, UCSB)

(Chen, U Arizona)

www.smartmoney.com
access & exchange

• participants

(Viégas & Donath, MIT)

(Kirk & Selfridge, AT&T)

Roelofs & van der Meulen, Philips, CA
infovis challenges

technical/engineering issues...
• scalability
• graphics/information density
• speed and efficiency

theoretical issues...
• lack of theory
• does it work?
• usability
• very little empirical evidence

CS/EE
HCI
cartography

HCI
cognitive science
information science
GIScience etc.
infovis challenges

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graphic representation of meaning

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(Fabrikant, 2000; Fabrikant and Buttenfield, 2001)
semantic generalization

ontological design

what exists

what it represents

real world

geographic environment

feature

feature location

world has time

scale

source domain

context

semantic world

data archive

semantic entity

entity location

space is time

granularity

target domain

metaphorical mapping

object & relations
target domain mappings

- semantic primitives
- entity
- trajectory
- boundary
- aggregate area
target domain mappings

Semantic primitives

Semiotic primitives

Entity

Trajectory

Boundary

Aggregate area

Scale

Point

Line

Line/area

Area
target domain mappings

(Bertin, 1967, MacEachren, 1995)
an example
FOCUS-Confusion over Afghan hijack motives Jane Barrett

AFGHAN PLANE 5THLD (PICTURE, GRAPHIC)

STANSTED England British police restored calm on a hijacked Afghan airliner on Wednesday after the surprise escape of the four-man flight crew had sent tension soaring. But confusion reigned over the motives of the hijackers. Kabul's national airline said it could be a mass asylum bid but British police said they were "not aware of any asylum applications." "We are back on an even keel now -- overnight there was a degree of tiredness and frustration," said a spokeswoman for Essex police handling the hijack at Stansted airport east of London. Assistant chief constable Joe Edwards said the crew escaped using a rope ladder through a cockpit window at around 1045 GMT on Tuesday after "up and down" negotiations with the hijackers, who took over the plane after it took off from Kabul on Sunday. [...]

XML extracts from starlight database
• automatically indexed and formatted

one article out of 504
latent semantic analysis (LSA)

- **latent semantic indexing (LSI)** (Deerwester et al., 1990)
  - automatic indexing by latent associations of terms
  - based on semantic proximity

- large vector space of term-document associations
  - two mode factor analysis (singular value decomposition)
  - SVD into term-term, doc-doc, term-doc matrices
  - terms and documents are vectors in \( n \)-dimensional space

- **angular proximity is similarity between documents**
  - e.g. cosine or dot product

- **result: document * document proximity matrix**
spatialization in two steps

preservation of meaning through abstraction
• semantic generalization
  – source domain ontologies
    • geographic primitives: features, regions, boundaries
    • formalized spatial structure: space types, scale continuum

graphic representation of meaning
• semiotic generalization
  – target domain mappings
    • semantic primitives: locations, regions, networks
    • formalized symbology: sign-vehicles

(Fabrikant, 2000; Fabrikant and Buttenfield, 2001)
task primitives

describe, summarize, locate
features ➔ entities

- one reuters article

spring-node algorithm
(Kamada and Kawai 1989)
task primitives

categorize, distinguish, compare
regions ➔ aggregates
scale 1:2

intramax (Masser and Brown 1975),
voronoi tessellation

economy
world affairs
task primitives

identify, associate, locate
scale ➔ level of detail
task primitives
relate, associate, emphasize
paths ➔ trajectories

pathfinder (Schvaneveldt and Durso, 1988)
task primitives

enjoy the fruit salad!
boundaries, paths ➔ trajectories
task primitives
filter, reveal
mt. rigi in winter
information filter
scale 1:4
information density scale 1:9
conclusions & outlook

- spatialization for accessing knowledge buried in databases
- robust spatialization must be based on
  - a sound theoretical framework (guidelines for design)
  - formalized design (validated by usability evaluation)
- GIScience provides theoretical basis for usable spatialization