Spatial Information Technology Past, Present, and Future

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Goal

GIS has changed:

- from the tool for public administration, operated by specialist
- to the GIS for everybody and everywhere.

- What triggers the changes?
- What demands have users?
- What are the economic effects?
- What are consequences for the profession?

Review by (roughly) decades

The stages of my professional career:

- 1975 - 1982 ETH Zürich
- 1982 - 1992 University of Maine, USA
- 1992 - 2002 TU Wien
- 2002 - 2014 TU Wien
- 2014 - 2024

Focus:

> *The effects of technology on the processing of geographic information in practice.*
> *It is not important when a new device or method was announced,*
> *but when it was really used (judged from my memory)*

Outline

The experimental beginning

Two very early (first) conferences

- 1977 Harvard Computer Graphics Lab
- 1979 Landinformationssysteme - Darmstadt

mainframe, laser distance meter with heavy batteries, pocket calculator

Outline

LIS or GIS?

Should it be

- Land Information Systems or
- Geographic nformation System?

Definition of FIG for LIS established in 1981 Montreux, today used for GIS.

Advanced city administrations such as Vienna, Basel, Hamburg install systems.
The US reports of cost effective facilities management for electricity, gas and water suppliers.

Research:

- Data structures for for the storage of spatial data, for quick cartographic output.
- Logical structuring of spatial data,
- **“navigable data”** as a new requirement.
- Quality of data.

Outline

Technology

- Databases on mainframes,
- GIS on minicomputers ($>$ 200,000 €),
- networked with
- few graphics-capable terminals ($>$ 30,000 €).
- IBM PC is pushing (MS-DOS)
- computer networks in the U.S. universities.

Networks and graphical output

- Local networks connect smaller computers so that several workplaces are possible.
- graphic screens become affordable,

GIS programs are offered by various companies,

- the data structures are proprietary
- and the exchange of data is severely obstructed.

Research

The U.S. National Science Foundation is establishing a National Center for Geographical Information and Analysis. It should advance research in

- spatial analysis and statistics,
- spatial relationships and data structures,
- expert systems for spatial tasks, and
- explore legal and economical aspects of spatial data.

The three universities:

- University of California, Santa Barbara,
- State University of New York, Buffalo, and
- University of Maine, Orono

operate the NCGIA starting 1988.

Software

Proprietary GIS programs are converted from (expensive) mini computers to PC.
The Open Geospatial Consortium (OGC) was founded to facilitate the exchange of data and the joint evaluation of data from different sources

In cooperation with other international standardization bodies (ISO etc.), standards for exchange of spatial data emerge.

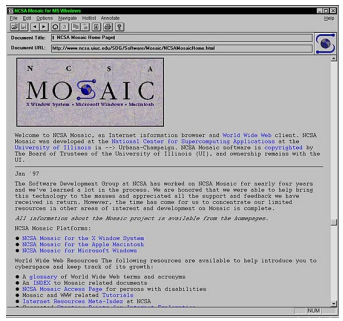
Outline

Technology

PCs with an “MS-windows” graphic interface are

- available at practically every office desk
- onnected to the WWW.

Thanks to the web browser, access to data is easy worldwide.
Portable PCs are spreading:



Network

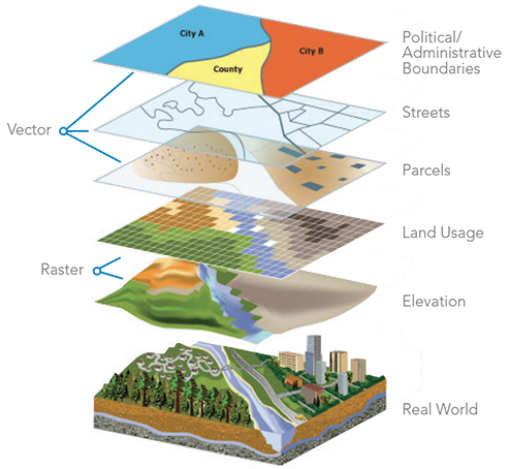
- The Internet is opened for everybody.
- Electronics and radio technology can be packed
  - with enough batteries
  - in a format that fits in one hand or trouser pockets.
- Mobile telephony - generally without web access, is spreading rapidly.

Research

Integration of data from different sources could achieve the dream of a comprehensive GIS from 1970:

- web technology is ready
- only standards for data exchange are missing.

Advertising for services and goods targeted by position of potential client demonstrates effective.



Geographic Information Practice

Thanks to the available data in the USA:

- car navigation combines
  - inexpensive GPS receivers with
  - low resolution displays and a microcomputer -

Car navigation is probably the first GIS application for everybody!

Outline

Technology

The downsizing of the computer components allows a PC to be packed in the size of a cell phone:
the smart phone always has web access always and everywhere!

Public administration data

- In the UK, administration data from the government, including geodata, are released free of copyright.
- An industry for the commercialization of refinement of such data emerges quickly.
- Other countries in Europe give up restrictive practices, mostly without including precise measurement data or complete coverage.

For many applications, geodata from Google Map and Open Street Map, are used

Geographic information practice

Very many applications are require detailed road maps.

- Companies like Google collect uninterpreted street images.
- The Open Street Map project collects geodata with volunteers; the procedures are so refined that a lay person with a smart phone can quickly create maps. This is important in a disaster area.



Outline

Are predictions possible?

Drivers for changes are tasks that people have to solve. When new technologies **enable** new approaches to perform these tasks more economically, new products become possible.
Example: Task to send a message to another person
- solution with a mobile phone is more convenient than
- using the landline, and preferable if the costs are comparable.

- Changes are predictable because
- human needs are mostly constant.

The development of new products from idea to market penetration takes more than 15 years.

Drivers for change are:

The drivers pushing for new technology are

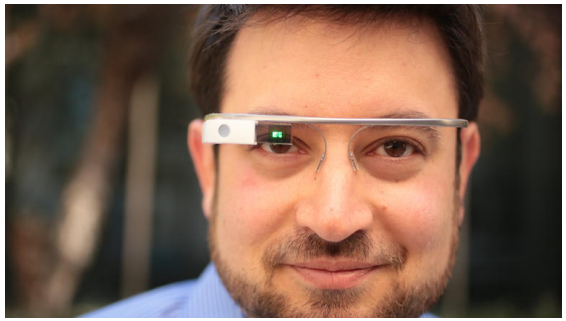
- economical - the same need can be satisfied at lower cost.
  Lower cost results from
  - New technology (hardware and software)
  - Cost reduction by mass marketing
- Change in social demand
- Data becomes available (collected for other purpose).

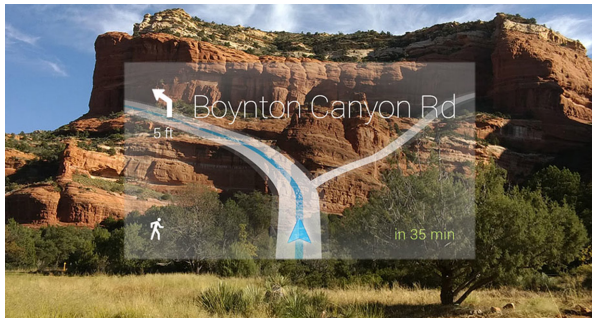
Technology future

Computer technology will continue to develop in the same direction as before:

- smaller and with less power consumption
- multiple cores for parallel processing (but the single cores are not faster)
- better batteries.

Wearable computers can be built into cloths, or a display integrated into glasses.





Semantic Web

The basic idea of the Semantic Web is simple:

- Construction of globally unique identification key of facts as "<subject> has < property> with <value> " triple
- Different classification are indicated by different keys (a.k.a. everybody uses his own classification)

Data exchange as semantic layer above established WWW protocols with standardized query language (SPARQL)
Ontology as a logical layer superimposed on the facts

Application using "natural language"

Use of natural language are increasingly built into geographic applications
For example: cell phone applications can answer simple questions
Important privacy concerns remain.
The main obstacle to GIS and other IT systems is the difference between the automatic processing of characters and the human understanding of these words (a.k.a. semantics).
Statistical methods can recognize patterns in large amounts of data, which is a good substitute for human understanding, for example in automated translation of text or conversion of spoken language into actions when driving a vehicle.
Statistical solutions work often but do not explain how.

Challenge "autonomous car"

Location and spatial information are central to the development of autonomous cars.
Technical challenges are numreous but likely solvable.
Social questions which must be legislated:

- Who is responsible for accidents?
- To whom belong the data collected?
- How to assure "normal cars" can co-exist with the autonous ones?

Social challenges

Geographic information is central to further integration of IT in applications.
Geographic information is the information where we are and where we have been. It reveals a lot about us. Concerns:

- protection of privacy
- cyber crime
- interaction with others, real, virtual and in social networks.
- assessment in political processes to allow new Approaches.
  - Who benefits, who suffers?

GIS practice

Temporal GIS GIS is moving from the static representation of the "current" state to the dynamic recording of the changes and the processes that cause change.

Gameification Merging "real" GIS with games, virtual only or mixed virtual and real world.

Computer crime

Our social systems are increasingly dependent on computer systems which are
often not well protected.
Public key encryption will be more used to increase privacy

Potential for criminal abuse will make some business models not viable.

The opportunity of the Corona virus pandemy

Evolution (biological or socio–economical) can not step backwards
except after a catastrophy (e.g. the extinction of dinosaurs).
After "Corona" for the restart of economy:

- What technology is desirable?
- How to avoid undesirable development (repeated)?

Forces which lead to undesirable solutions

Extreme push for cost reduction (without full assessment of cost and benefits) removed redundancy and made systems vulnerable.

- Transportation benefits from economic externalities.
  - Information technology reduces benefits of proximity.

  -> centralization and globalization.

Global companies are as big as large countries;

- appropriate parts from the commons what is for everybody to use and use it exclusively.
- benefit from local services but avoid contributions. Lack of tax income pushes for reduction in social services.

Outline

GIS history: Technology became available:

Technical development:

- Electronics and electrical engineering,
- Software (made possible by more computing power)
- Batteries

Price and size are decisive!

Four phases of geographic information

- 1970: Computers appear
  - Computers can, e.g. process geometry, draw, save
  - GIS experiments
  - Centralization and interactive systems; GIS uses database concept
  - - > Comprehensive GIS for specialists planned
- 1990: GPS, PC, networking
  - smaller units -> Distributed use

Geoinformation for everybody

- 2000:
  - wire based networks
  - Google Maps,
  - inexpensive GPS
  - car navigation
- 2010: mobile + network = smart phone
  - GIS everywhere and for everybody!
- Future: semantic web

Demand for spatial information remains constant

Humans want to understand where they are and how the situation around them changes.
Waldo Tobler's first law of geography: Every thing influences everything, but nearby things influence more!