Gábor Bartha

Geoinformation
master course

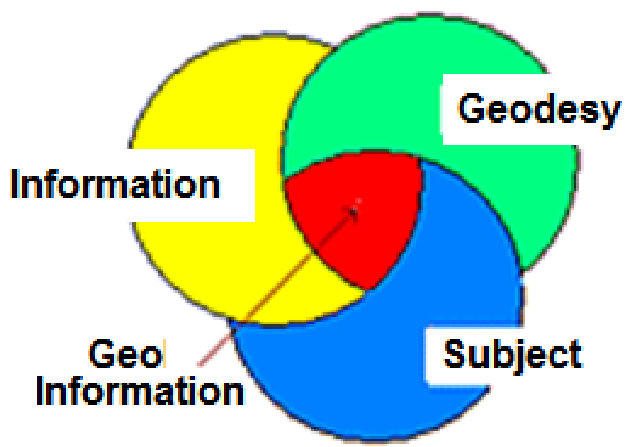
University of Miskolc 2014

1. BASIC CONCEPTS OF GEOINFORMATION

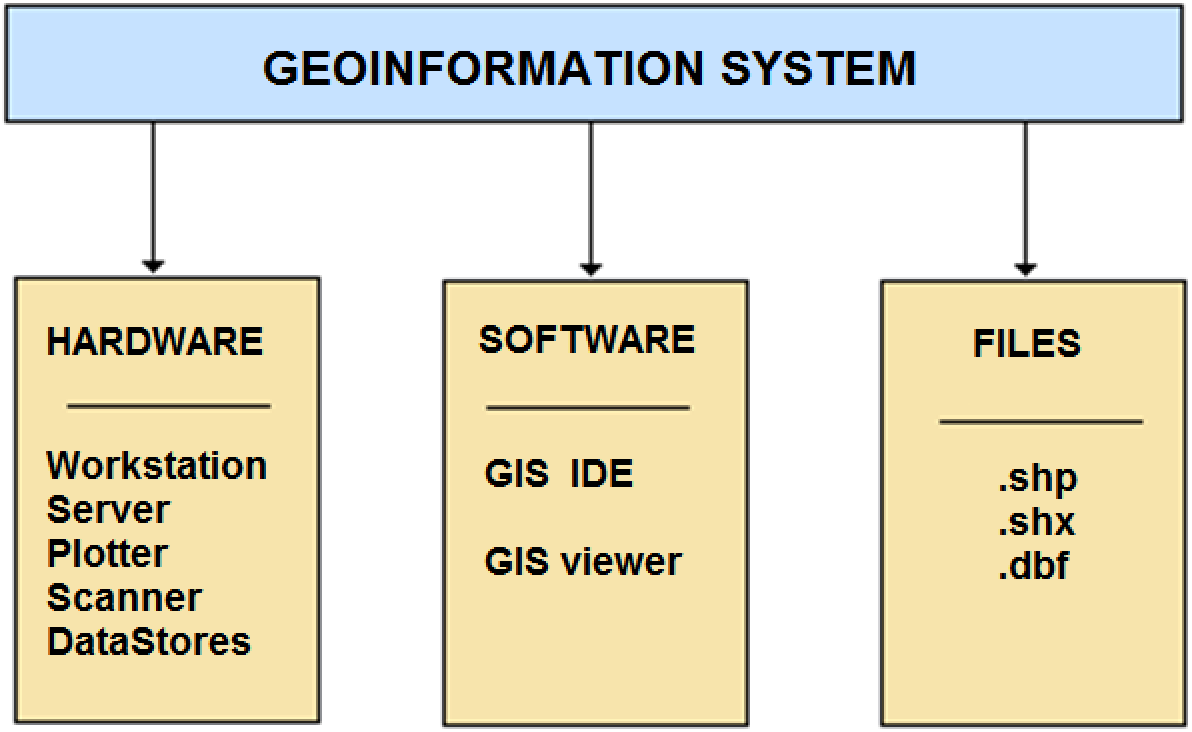
<u>subject:</u> display, store and analyse data related to a geographical location

<u>levels:</u> Thematic Maps, Geographical Information System, Expert System

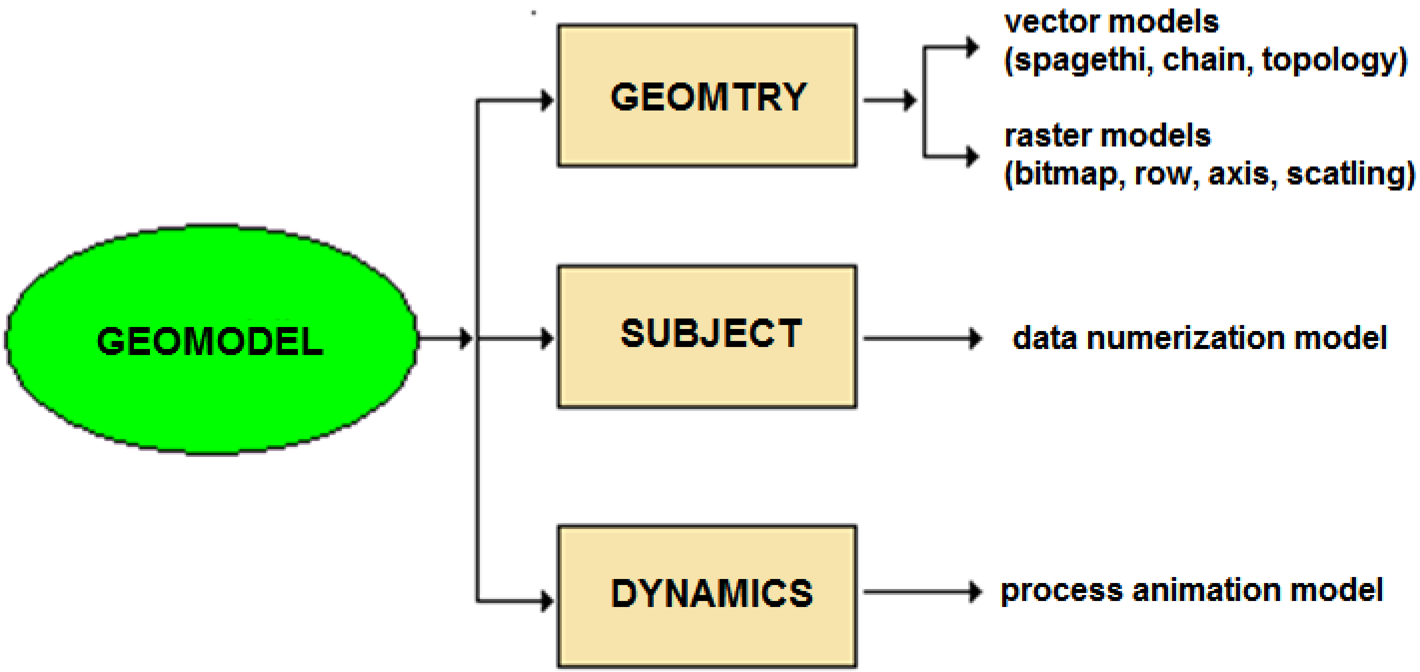
<u>backgrounds</u>



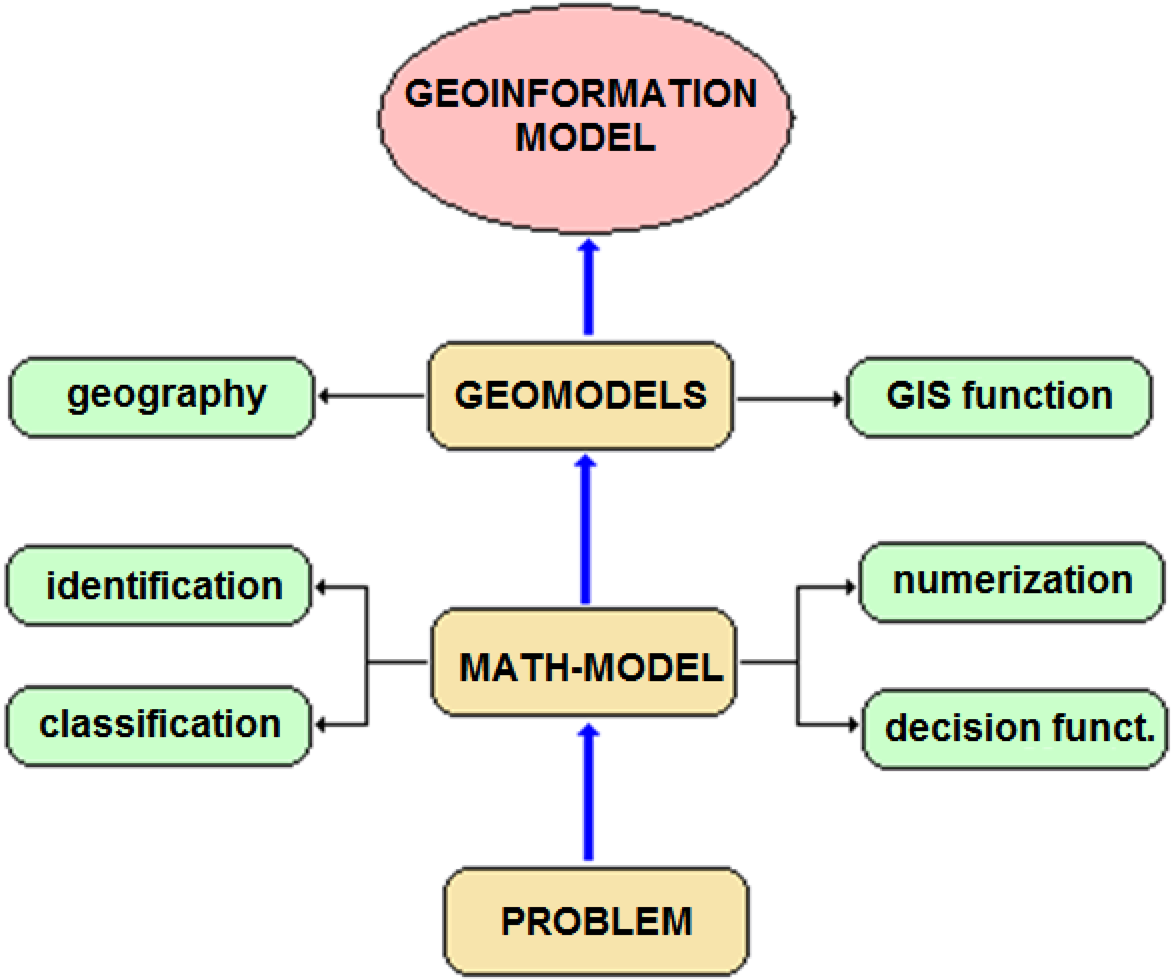
Geoinformation System:
computer system for solving geoinformation problems



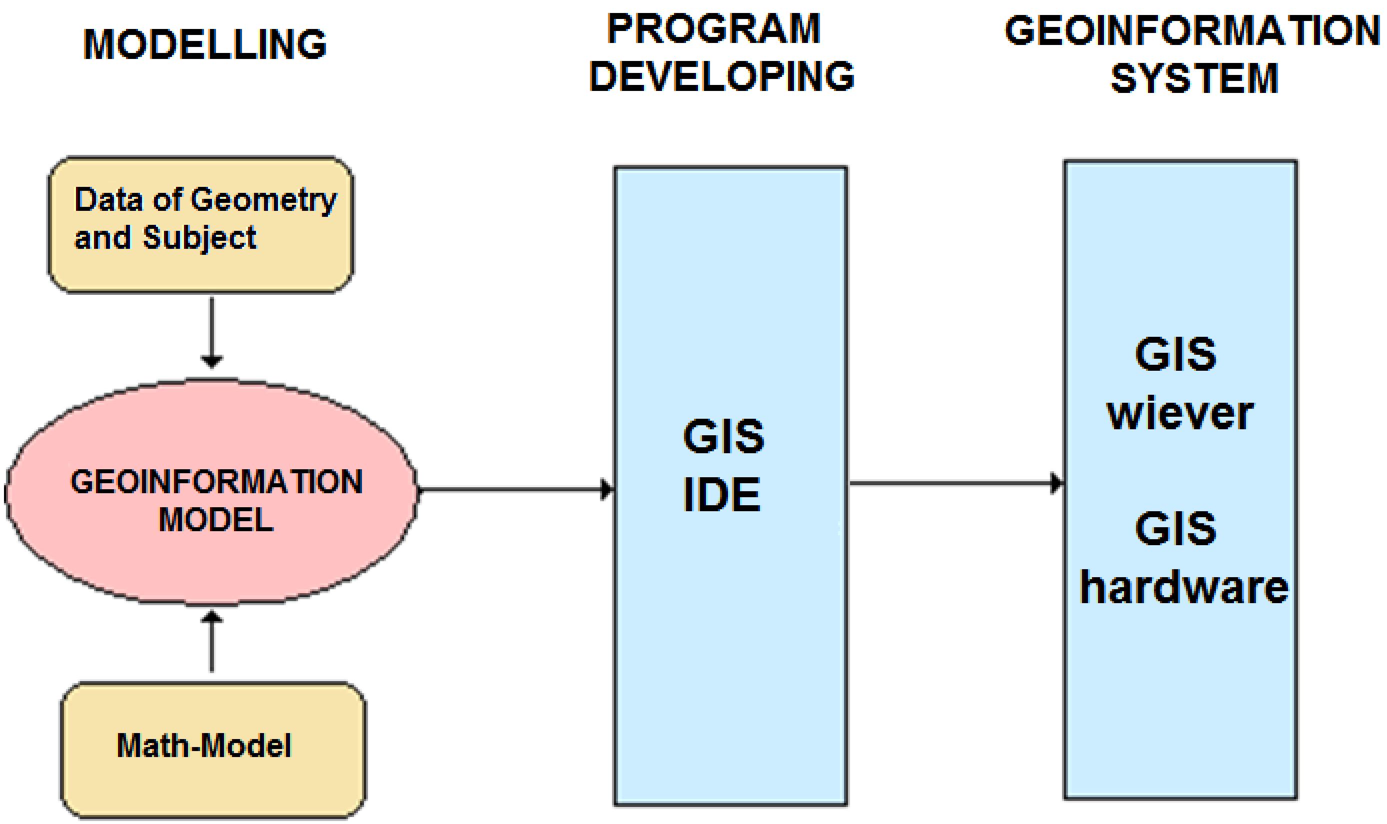
Geoobject: collection of identical points
Geomodel: computer image of geoobject



Geoinformation model: geoinformation layout of a problem



Developing of Geoinformation System:



Formulation of a problem: Locate the optimal pasture for cows to make them happy (producing us a lot of milk) !

Mathematical model is constructed in two steps:

1. Identification and classification of important factors :

- Cows do not like the stony areas (disclosing factor);
- Cows do not like the slopy areas (disclosing factor above a restricted range)
- Cows like close drinking water (not disclosing factor)
- Cows like good quality grass (not disclosing factor)

2. Numerization of factors and Objective Function

Factor	**Notation**	**Classification**	**Value**	**Numerical Value**
Area	T	disclosing	stony not stony	0 1
Slope	L	disclosing	greater than 20% between 10-20%	0 0.5 1
Drinking Water	V	Not disclosing	more than 1 km between 0.5-1 km	0.2 0.5 1
Quality of Grass	F	Not disclosing	medium good excellent	0.5 0.75 1

Objective Function: **$f = T*L*(V+F)$**


MIKOR BOLDOGOK
A TEHENEK?

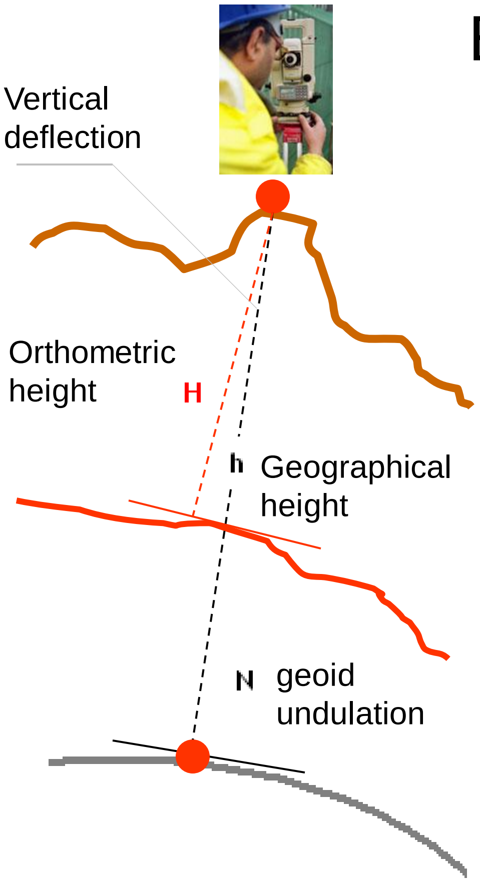
2. GEODESY BASICS

Friedrich Robert HELMERT
(1843-1917)

„the task of geodesy is to determine the shape of the Earth and to map its surface"

1. Shape and Surfaces of the Earth
2. Coordinate Systems of the Earth
3. Projection Systems

Earth Surfaces: topographic, geoid, ellipsoid



N + H = h

TOPOGRAPHIC SURFACE – mathematical description is not known → Where we measure

GEOID
Physical concept - an equipotential surface of gravity field - mathematical description is not known → Where we fix the instrument

NORMAL ELLIPSOID
Geometrical concept – mathematical description is known → Where we define the coordinates

$$(x^2 + y^2)/a^2 + z^2/b^2 = 1$$

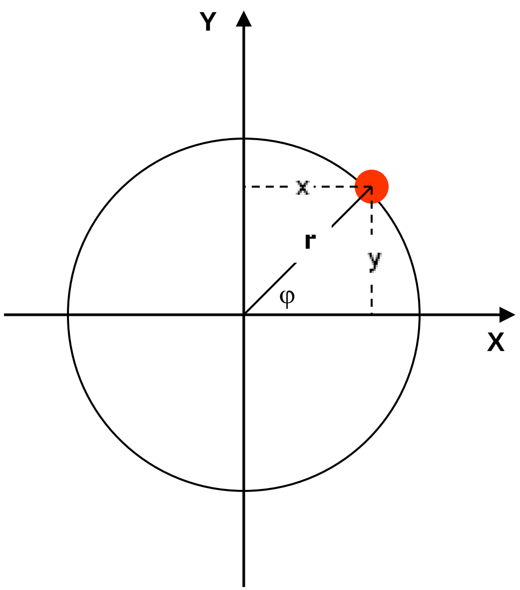
Eart Coordinate Systems: metrics and length

René Descartes
Renatus Des Cartes
(1596-1650)

Bernhard Riemann
(1826 -1866)

$$X = \begin{vmatrix} x \\ y \end{vmatrix} \qquad Q = \begin{vmatrix} r \\ \varphi \end{vmatrix} \qquad \begin{aligned} x &= r\cos\varphi \\ y &= r\sin\varphi \end{aligned}$$

Orthogonal - Curvelinear (Cartesian - Riemann) coordinate vectors



$$dX = (\partial X / \partial Q) \quad dQ$$

$$\begin{vmatrix} dx \\ dy \end{vmatrix} = \begin{vmatrix} \partial x/\partial r & \partial x/\partial \varphi \\ \partial y/\partial r & \partial y/\partial \varphi \end{vmatrix} \begin{vmatrix} dr \\ d\varphi \end{vmatrix} = \begin{vmatrix} \cos\varphi & -r\sin\varphi \\ \sin\varphi & r\cos\varphi \end{vmatrix} \begin{vmatrix} dr \\ d\varphi \end{vmatrix}$$

Jacobi matrix

Infinitezimal Difference

$$dX^2 = (dX)^T(dX) = dQ^T (\partial X / \partial Q)^T(\partial X / \partial Q)\, dQ$$

$$\begin{vmatrix} dx & dy \end{vmatrix} \begin{vmatrix} dx \\ dy \end{vmatrix} = \begin{vmatrix} dr & d\varphi \end{vmatrix} \begin{vmatrix} 1 & 0 \\ 0 & r^2 \end{vmatrix} \begin{vmatrix} dr \\ d\varphi \end{vmatrix}$$

$$dx^2 + dy^2 = dr^2 + r^2 d\varphi^2$$

Length
Coordináta Invariant

Polar Coordinates
orthogonal but not orthonorm

length ^{2} = (Coordinata Vector)^T (Metric Tensor) (Coordinate Vector)

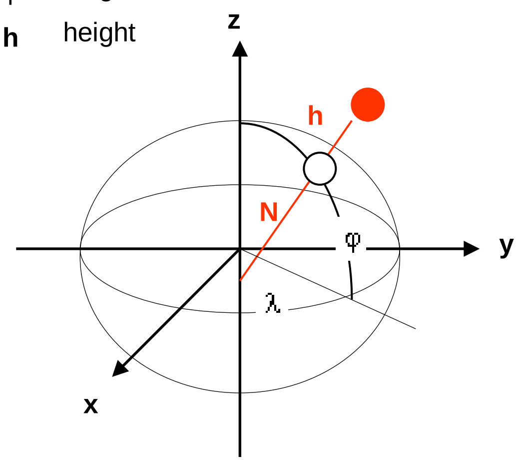
Jacques Cassini (1677-1756)
Arc to North was shorter than the Arc to East, however, they belonged to the same angle. It proved that the Earth's shape is NOT spherical but ellipsoidal

Geodetic System – Geodetic Curvelinear Coordinates

λ latitude

φ longitude

h height



$$X = \begin{vmatrix} x \\ y \\ z \end{vmatrix} \qquad Q = \begin{vmatrix} \lambda \\ \varphi \\ h \end{vmatrix}$$

$$x = (N+h)\cos\varphi\cos\lambda \qquad e^2 = 1 - b^2/a^2$$

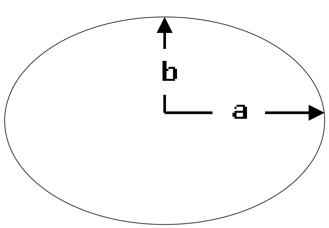
$$y = (N+h)\cos\varphi\sin\lambda \qquad N = a(1 - e^2\sin^2\varphi)^{-1/2}$$

$$z = (M+h)\sin\varphi \qquad M = N(1 - e^2)$$

$$dX^2 = (dX)^T(dX) = dQ^T(\partial X/\partial Q)^T(\partial X/\partial Q)\,dQ$$

arc

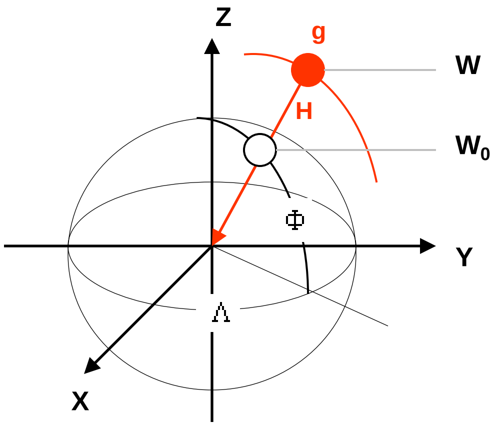
$$\begin{vmatrix} dx & dy & dz \end{vmatrix}\begin{vmatrix} dx \\ dy \\ dz \end{vmatrix} = \begin{vmatrix} d\lambda & d\varphi & dh \end{vmatrix}\begin{vmatrix} (N+h)^2\cos^2\varphi & 0 & 0 \\ 0 & (M+h)^2 & 0 \\ 0 & 0 & 1 \end{vmatrix}\begin{vmatrix} d\lambda \\ d\varphi \\ dh \end{vmatrix}$$

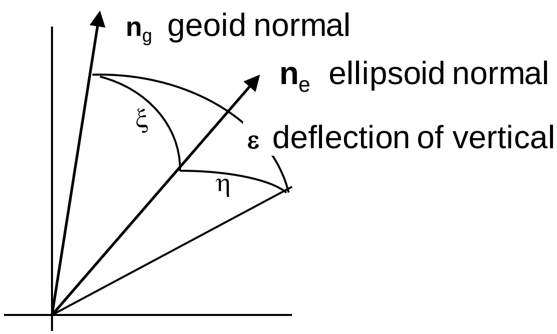


$$dx^2 + dy^2 + dz^2 = (N+h)^2\cos^2\varphi\, d\lambda^2 + (M+h)^2 d\varphi^2 + dh^2$$

Geodetic Coordinates are ortoghonal, but not orthonorm

Lóránt Eötvös (1848-1919)





Astromomical Systems – Astronomical Coordinates

Lcal | **Global Cartesian** | **Global Curvelinear**

ASTRONOMICAL SYSTEMS

$$\mathbf{x} = \begin{vmatrix} x \\ y \\ z \end{vmatrix} \qquad \mathbf{X} = \begin{vmatrix} X \\ Y \\ Z \end{vmatrix} \qquad \mathbf{Q} = \begin{vmatrix} \Lambda \\ \Phi \\ \Delta W \end{vmatrix}$$

$$g_X = -g \cos\Phi \cos\Lambda \qquad \eta = (\Lambda - \lambda)\cos\Phi$$

$$g_Y = -g \cos\Phi \sin\Lambda \qquad \xi = \Phi - \varphi$$

$$g_Z = -g \sin\Lambda \qquad \Delta W = W - W_0 = g\,H$$

The difference of equipotencial surfaces :

$$\Delta W = W_x + W_y + W_z + \tfrac{1}{2}(W_{xx}x^2 + W_{yy}y^2 + W_{zz}z^2) + W_{xy}dxdy + W_{xz}dxdz + W_{yz}dydz\ \ldots$$

Elements of ΔW are the gradient of gravity vector (Eötvös tensor):

$$\text{grad } g = \begin{vmatrix} W_{xx} & W_{xy} & W_{xz} \\ W_{yx} & W_{yy} & W_{yz} \\ W_{zx} & W_{zy} & W_{zz} \end{vmatrix}$$

$$\partial\Phi/\partial x = W_{xx}\ /\text{-}g \qquad \partial\Phi/\partial y = W_{xy}\ /\text{-}g \qquad \partial\Phi/\partial z = W_{xz}\ /\text{-}g$$

$$(\partial\Lambda/\partial y)\cos\Phi = W_{yy}\ /\text{-}g \qquad (\partial\Lambda/\partial z)\cos\Phi = W_{yz}\ /\text{-}g$$

$$\partial W/\partial x = 0 \qquad \partial W/\partial y = 0 \qquad \partial W/\partial x = -g$$

from geometry

Infinithesimal displacement in curvelinear coordinates:

$$\begin{vmatrix} d\Phi \\ d\Lambda \cos\Phi \\ dW \end{vmatrix} = -(1/g) \begin{vmatrix} W_{xx} & W_{xy} & W_{xz} \\ W_{yx} & W_{yy} & W_{yz} \\ 0 & 0 & 1 \end{vmatrix} \begin{vmatrix} dx \\ dy \\ dz \end{vmatrix}$$

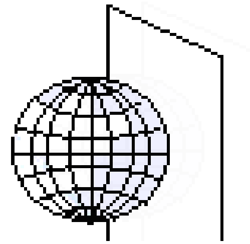
$$\oint dx \neq 0 \qquad \oint d\Phi = 0$$

$$\oint dy \neq 0 \qquad \oint d\Lambda = 0$$

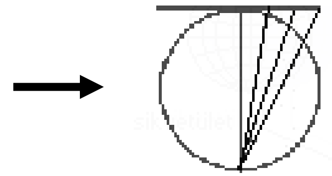
$$\oint dz \neq 0 \qquad \oint dW = 0$$

closing error

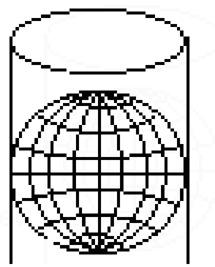
Astronomical Cartesian coordinates are orthonorm
Astronomical curvelinear coordinates are not orthonorm



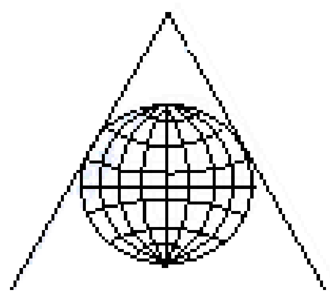
planar projection



stereographical
planar projection



cylindrical projection



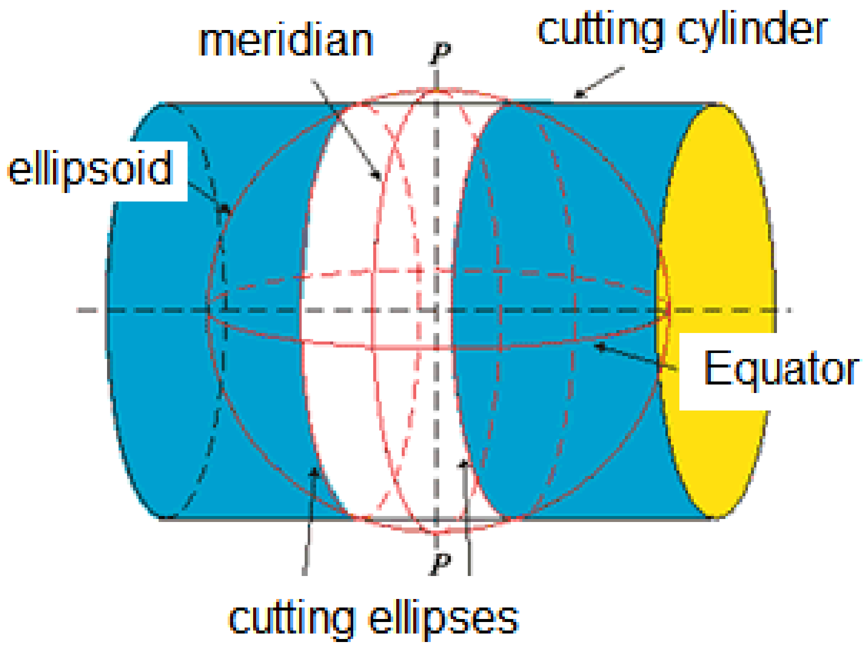
cone projection

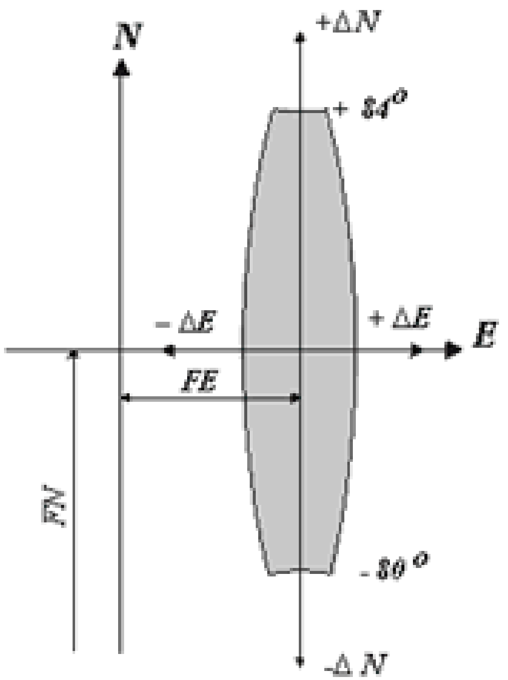
Reference Ellipsoids and Projections

Ellipsoid	**Hungarian Projection**	**Major Axis [m]**	**Flattening 1:f=(a-b)/a**
Bessel 1841		6 377 397	1:299.15
Clarke 1866		6 378 206	1:294.98
Hayford 1909		6 378 388	1:297.0
Krassovski 1942	Gauss-Krüger	6 378 245	1:298.3
GRS 1967 (Geodetic Reference System 1967)	EOV	6 378 137	1:298.25
WGS 1972 (World Geodetic System 1972)		6 378 135	1:298.26
WGS 1984 (World Geodetic System 1984)	UTM	6 378 137	1:298.25722

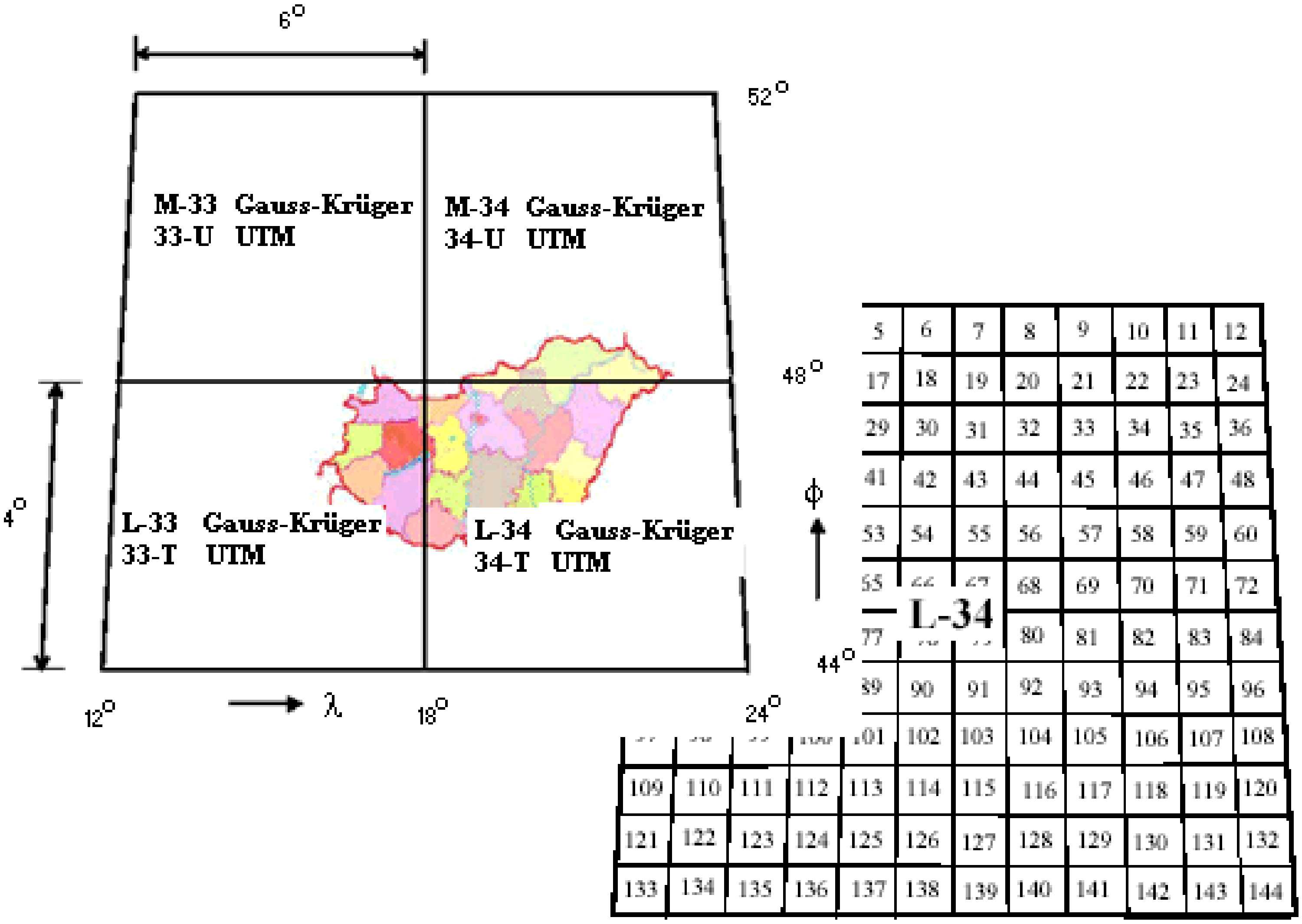
Hungarian Projections

Projection	Ellipszoid	Features	Use
Gauss-Krüger	Krassovski	Cylindrical isogonal transversal	Military - 1950
UTM Universal Transverse Mercator	WGS 1984	Cylindrical isogonal transversal	Military-civil - 2000
EOV Egységes Országos Vetület	GRS 1967	Cylindrical isogonal oblique	Civil - 1975

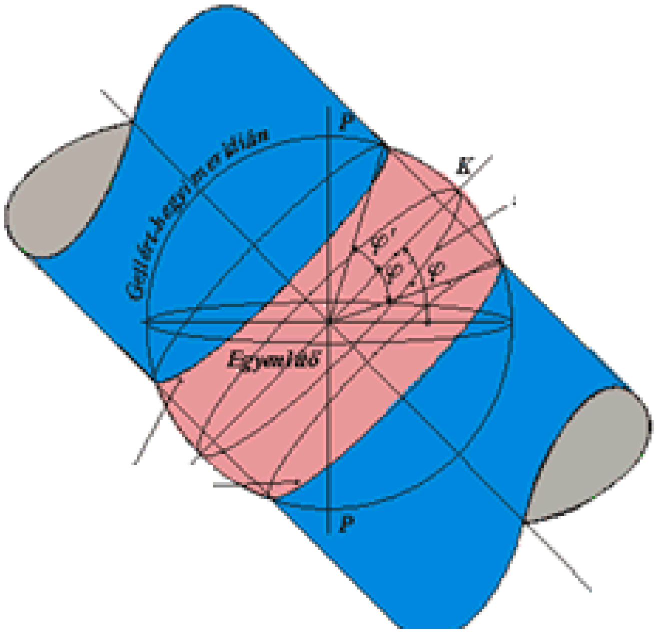

meridian
P
cutting cylinder
ellipsoid
Equator
P
cutting ellipses

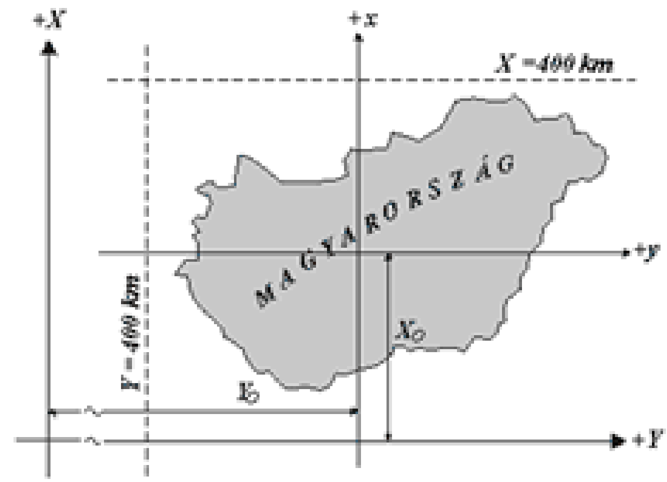

N
+ΔN
+ 84°
− ΔE
+ ΔE
E
FE
FN
- 80°
-Δ N

6º



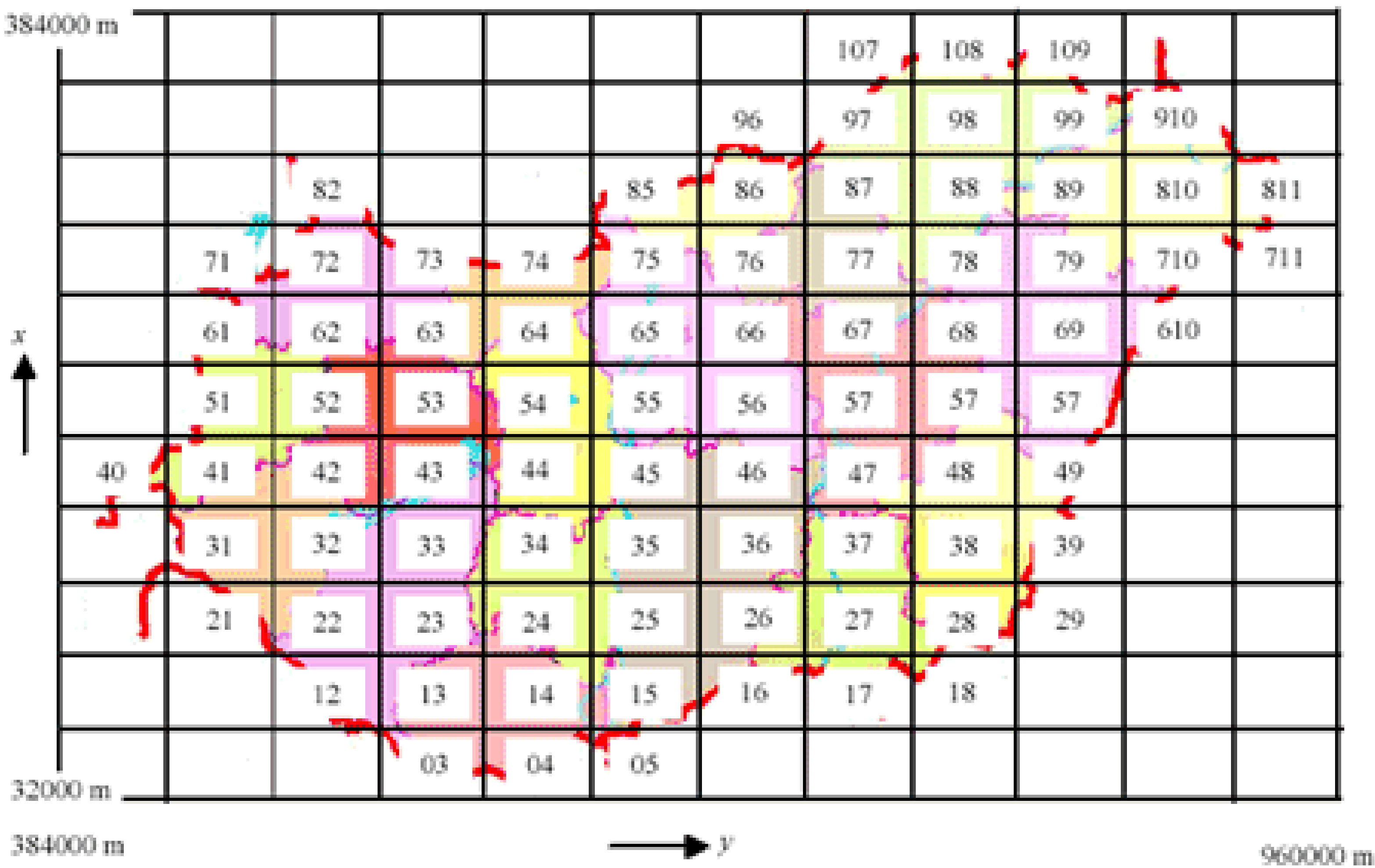
6°
52°
M-33 Gauss-Krüger
33-U UTM
M-34 Gauss-Krüger
34-U UTM
48°
4°
L-33 Gauss-Krüger
33-T UTM
L-34 Gauss-Krüger
34-T UTM
ϕ
44°
12°
λ
18°
24°
L-34

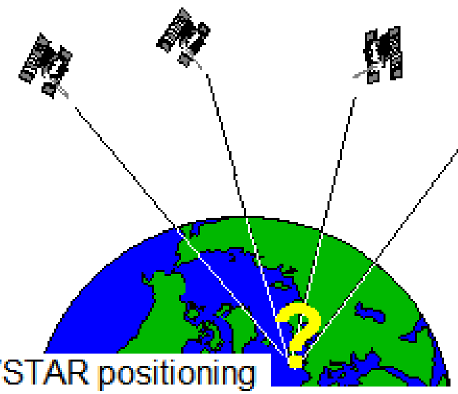

P
K
P


+X
+x
X =400 km
MAGYARORSZÁG
+y
Y = 400 km
X0
Y0
+Y

$x_{\text{alsó}} = 32000$ m; $x_{\text{felső}} = 384000$ m

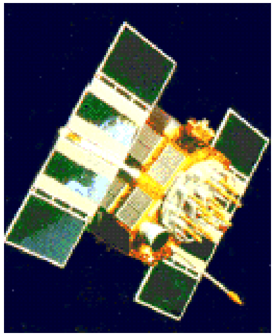
$y_{\text{bal}} = 384000$ m; $y_{\text{jobb}} = 960000$ m .

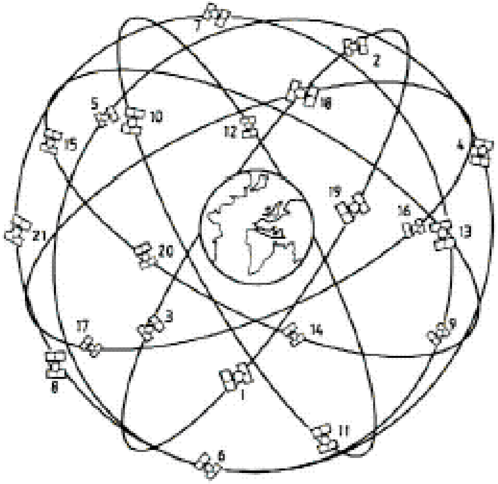




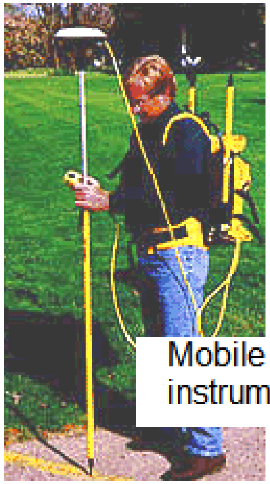
NAVSTAR positioning

NAVSTAR satellite



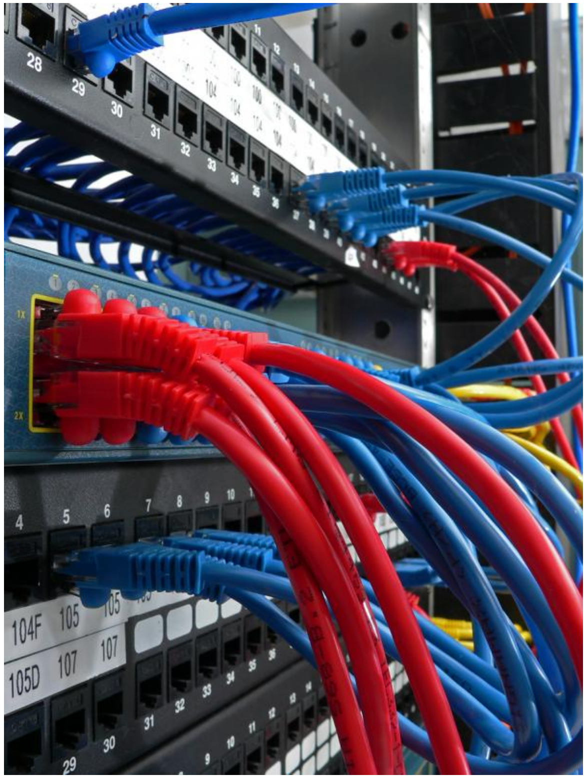


NAVSTAR system



Mobile measuring instrumentement

INFORMATION

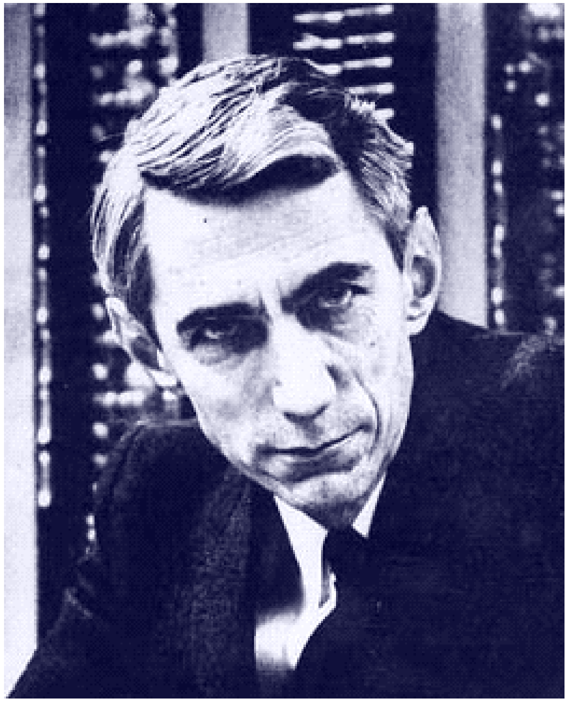


Information Theory

Hardware

Software

INFORMATION THEORY



CLaude Elwood Shannon
(1916 – 2001)

What is Information?

Communication Systems

Entropy

The BIT

Information Entropy

Performance of Communication System

What is information

Imagine yourself suddenly transported back in time to (say) the Iron Age. You meet a local ironsmith and you ask him "What is iron?" What kind of answer you likely to get? Very likely your craftsman would point to various artifacts he has made and inform you that each of those was iron. But this is not what you want. What you want to know is just what it is that makes iron **iron**... To give the kind of answer what would satisfy you, he would need to know all about the molecular structure of matter... But not only is your man not familiar with molecular theory, he probably does not even conceive of the possibility of such a theory!

[Keith Devlin]

scientis	theory	container	content	character	description
Devlin	situation	symbol	information	-	mat.logic model
Shannon	probability	message	information	-	stochastic model
Szilárd	Shannon	message	neg.entropy	material	information=neg.entropy
Wiener	Shannon	message	neg.entropy	spiritual	information=neg.entropy
Landauer	Shannon	message	quant. state	material	information=quant.state
MacKay	Shannon	message	structure	spiritual	change in receiver
Bateson	Shannon	message	structure	spiritual	Change caused change
Logan	biológia	cell	bio-info	biological	information=cell structure

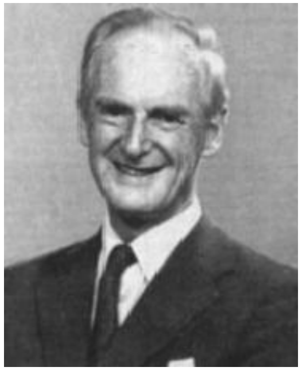
What is information

Today (several times called as Information Age), the situation of information professionals is much alike that of the blacksmith in Iron Age. They gather, store, manipulate, transmit information, they make their living from it. But they do not know what makes information to be **information**. When they talk on **Information Theory** they actually mean **Information Technology** (as we will do). The lack of underlying theory makes difficult to give a precise (or at least acceptable) definition of information *(more Bartha:'What is Information')*

Szilárd Leó

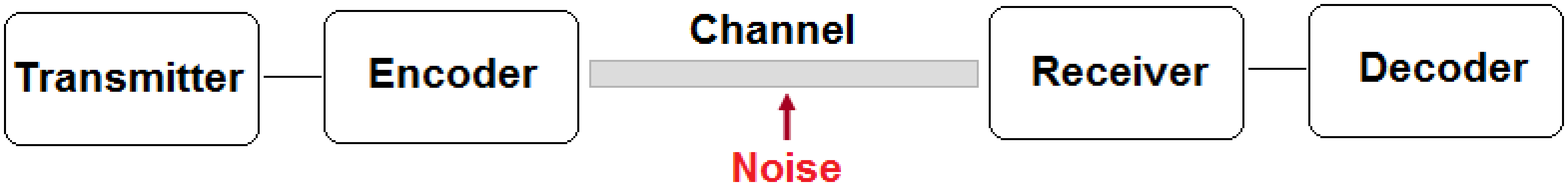
Shannon information is the negative entropy

Donald MacKay



Information is the change in the receiver mind's set

Communication System



Oh, bugger tradition – next time text me.

The caricature is a visualization of the Communication System. The transmitter is the fire and the smoke, the encoder the smoke-controller translating the message into smoke signal (e.g. ‘jerry is coming’= 1 smoke ring), the channel is the electro-magnetic field, the noise is the wind, the receiver is the other guy and the decoder his process decoding the smoke signal into the message. Mathematically:

Encoding: $\mathbf{F (A)}$ Decoding: $\mathbf{F^{-1} (A) = A}$

Communication System

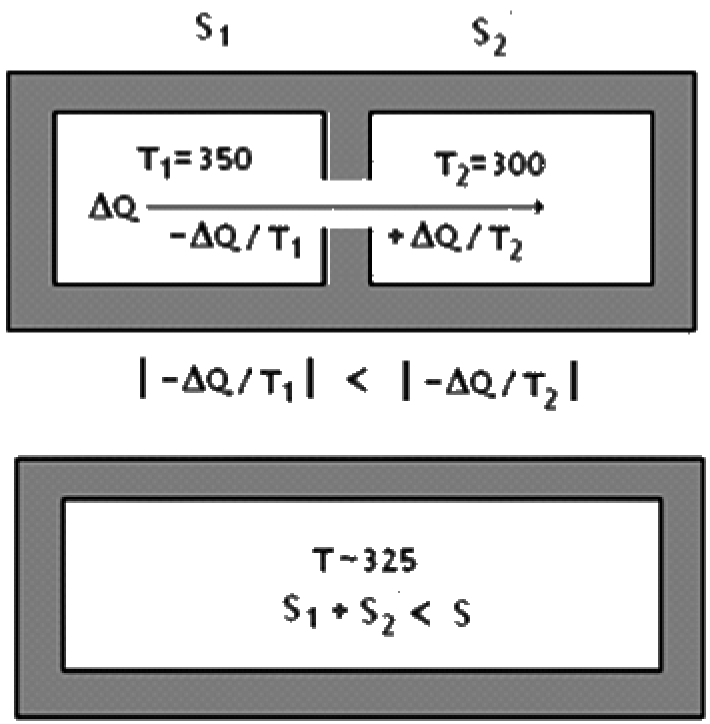
Information theory is a new branch of probability theory with extensive potential applications to communication systems... Wiener and Shannon in their discussion of the statistical nature of communication systems pointed out that a transmitter selects sequences of messages from a known transmitter vocabulary at random but with specified probabilities. Therefore such communication models must be statistically defined.... *[Fazlollah M. Reza]*

Therefore the performance of a communication system is based on laws of chance. If the source transmits a sequence of symbols denoted by **S** with probability of **P { S }** and the receiver gets a sequnce of symbol denoted by **R** with a probability of **P { R }**, then the common probability of transmitting and receiving the sequence i.e. the performance of the system is:

$$\mathbf{P\{S, R\} = P\{S\}\,P\{R\}}$$

Entropy

Statistical Mechanics



$$\Delta S = \Delta Q / T$$

(entropy)

<u>System:</u> mix of randomly wandering macroscopic particles

<u>Entropy:</u> expected value of a stochastic function describing the state of a system

$$S = \Sigma_i \, p_i f(p_i)$$

<u>Number of state is ADDITIVE parameter:</u> identical number in separated and unified condition: $f(p_i) + f(p_k) = f(p_i p_k)$

<u>Then function f is logarithmic function:</u>

$$f = \log(\ )$$

<u>Entropy:</u> $S = - k \, \Sigma_i \, p_i \ln(p_i)$

k = Boltzman constant

Measure of Information: the bit

Suppose selections $\mathbf{S}_k$ and $\mathbf{R}_j$ from sequence $\mathbf{S}$ and $\mathbf{R}$. The associated amounts of information are denoted as $\mathbf{X}_k$ and $\mathbf{Y}_k$. If the selections had equal probability, then the amount of information depends on the probabilities $\mathbf{P\{S_k\} = 1/n}$ and $\mathbf{P\{R_j\} = 1/m}$:

$$\mathbf{X_k = f\,(1/n) \qquad Y_k = f\,(1/m)}$$

The content is supposed to be **extensive (additive)** property that is the amount of information is the same either the selection was independent (**n + m** choice) or from the unified set (**mn** choice):

$$\mathbf{f\,(1/(mn)) = f(1/m) + f(1/n)} \quad \text{then} \quad \mathbf{f(x) = -\log x}$$

If $\mathbf{m=n=2}$ then $\mathbf{X_k = Y_k = -\log\,(1/2) = \log 2 = 1}$

1 bit = choice between two quantities

Information Entropy

If the selection has not equal probability the avarage amount of information per message is the **information entropy H(X)** :

$$\mathbf{H(X) = \overline{X_k} = \overline{- \log P\{S_k\}} = -\sum_k P\{S_k\} \log P\{S_k\}}$$

If pair of selections have done from two sets, the avarage amount information per pair is the **joint information entropy H (X,Y)** :

$$\mathbf{H (X,Y) = - \sum_k \sum_j P_{k\,j} \log P_{k\,j} \qquad P_{k\,j} = P\{S_k\}\, P\{R_j\}}$$

If pair of selections $\mathbf{X}_k$ and $\mathbf{Y}_j$ have done from two sets, and $\mathbf{Y}_j$ are known, then the avarage amount of information of $\mathbf{X}_k$ with condition $\mathbf{Y}_j$ is the **conditional information entropy H (X,Y)** :

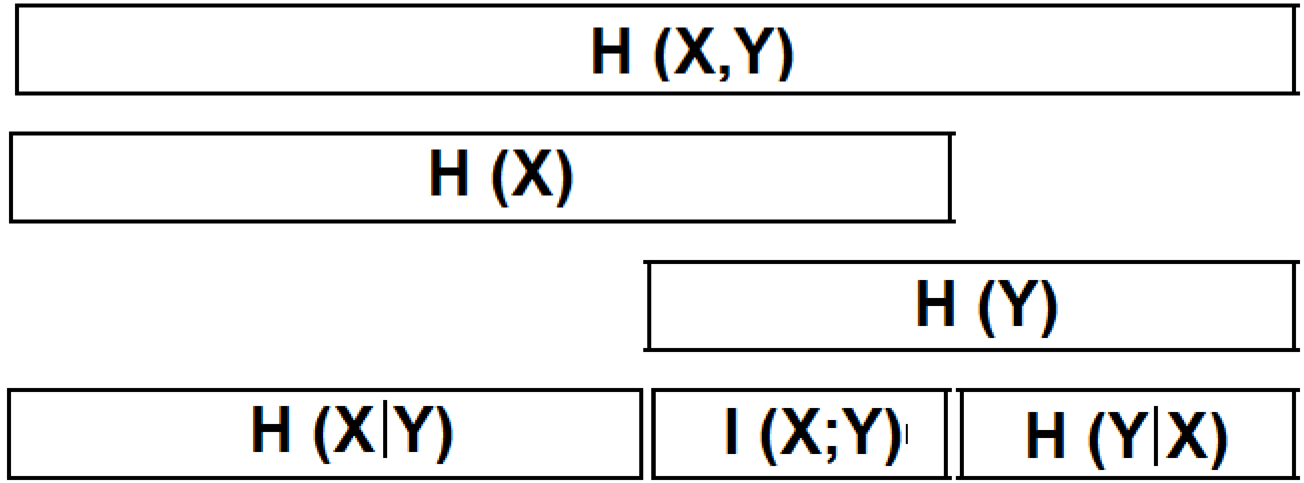
$$\mathbf{H (X \mid Y) = - \sum_k \sum_j p \{ X_k, Y_j \} \log p \{ X_k \mid Y_j \}}$$

If pair of selections $\mathbf{X}_k$ and $\mathbf{Y}_j$ have done from two sets, then the amount of information shared between $\mathbf{X}_k$ and $\mathbf{Y}_j$ is the **mutual information I (X;Y)** :

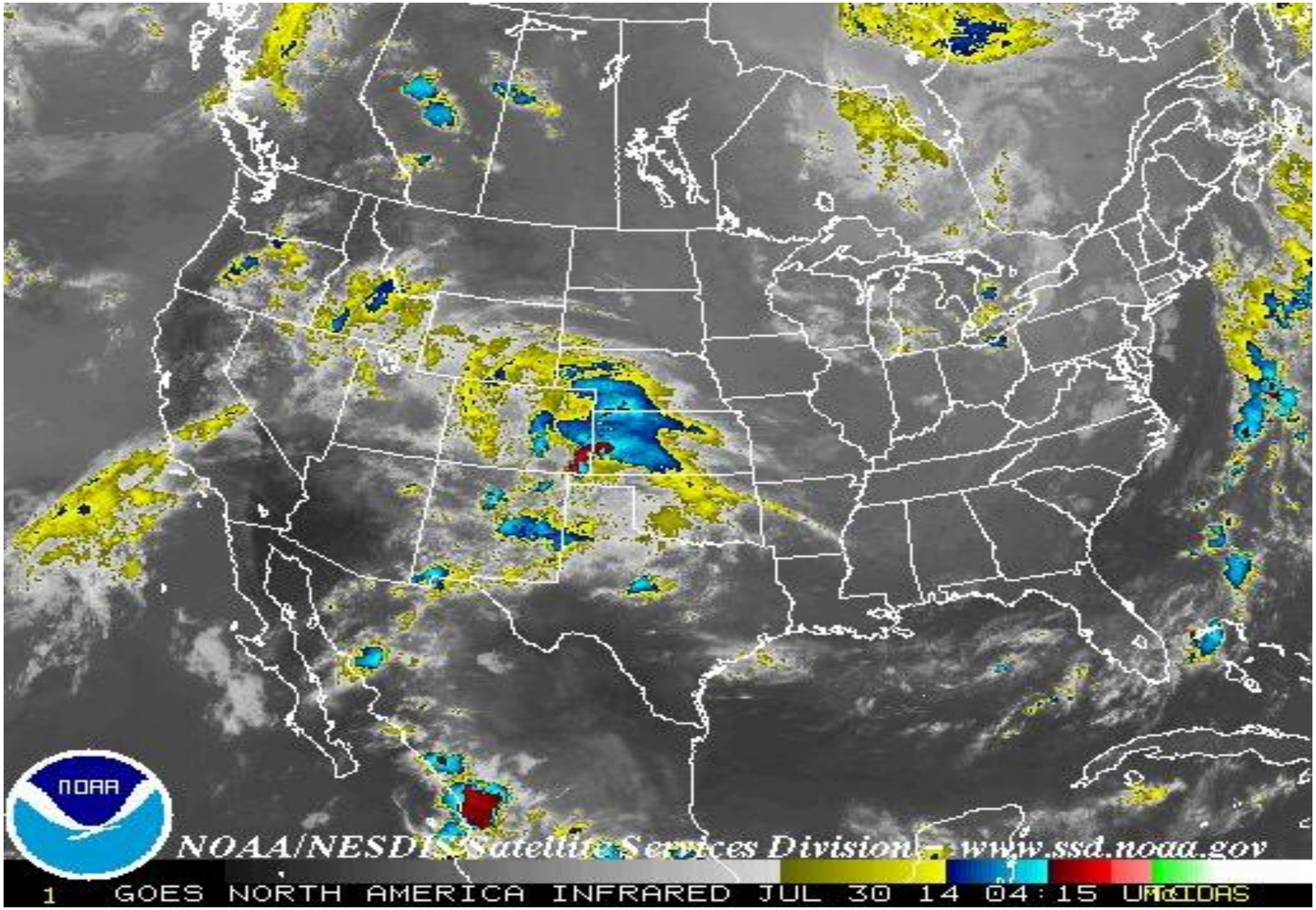
$$\mathbf{I\ (X;Y) = H(X) - H(X|Y)}$$

- It is a measure of how much **X** tells us about **Y**, and vice versa.
- If X and Y are independent then **I (X;Y) = 0**, because **X** tells us nothing about **Y** and vice versa.
- If **X = Y** then **I (X;Y) = H(X) = H(Y)**. **X** tells us everything about **Y** and vice versa.

The connections of the information entropies are well demonstrated by the next picture:



Example: Weather Service



The Weather Service observed that the sunny and rainy days are 60% and 40% while the hot and cold days are 60% and 40% on a territory. The 80% of hot days are sunny and 20% are rainy while 30% of cold days are sunny and 70% are rainy.

- What are the singular (marginal), the joint, the conditional information entropies of these data and the mutual information?

from Carlton Downey: An Introduction to Information Theory
http://alex.smola.org/teaching/cmu2013-10-701x/slides/R8-information_theory.pdf

$$H(X) = H(Y) = -\sum_k P\{Y_k\} \log P\{Y_k\}$$
$$= 0.6 \log(1/0.6) + 0.4 \log(1/0.4)$$
$$= 0.97$$

Marginal distribution

Y	hot	cold
P(Y)	0.6	0.4
X	sun	rain
P(X)	0.6	0.4

$$H(Y,X) = -\sum_k P\{Y_k, X_j\} \log P\{Y_k, X_j\}$$
$$= 0.48 \log(1/0.48) +$$
$$2\,[0.12 \log(1/0.12) +$$
$$0.28 \log(1/0.28)$$
$$= 1.76$$

Joint distribution

Y,X	hot	cold
sun	0.48	0.12
rain	0.12	0.28

$$\mathbf{H(Y|X)} = \sum_k \sum_j \mathbf{P\{Y_k, X_j\}\ logP\{Y_k|X_j\}}$$
$$= 0.48 \log(1/0.8) +$$
$$0.12 \log(1/0.2) +$$
$$0.12 \log(1/0.3) +$$
$$0.28 \log(1/0.7)$$
$$= 0.79$$

Conditional distribution

Y	hot	cold
P(YIX=sun)	0.8	0.2
Y	hot	cold
P(YIX=rain)	0.3	0.7

$$\mathbf{I(Y;X) = H(Y) - H(Y|X)}$$
$$= 0.97 - 0.79$$
$$= 0.18$$

Mutual information

- **I(X;Y) > 0**, therefore **X** tells something about **Y** and vice versa,
- **H(Y|X) > 0**, therefore **X** doesn't tell everything about **Y**

Performance of Communication System

If an associated pair of selections X_k and Y_j have done from the source and the receiver code set, respectively, then the maximum of shared amount of information i.e. the maximum of mutual information is the **communication channel capacity** C:

$$C = \max [I(X;Y)] = H(X) - H(X|Y)$$

Noise free channel: $H(X|Y)=0$

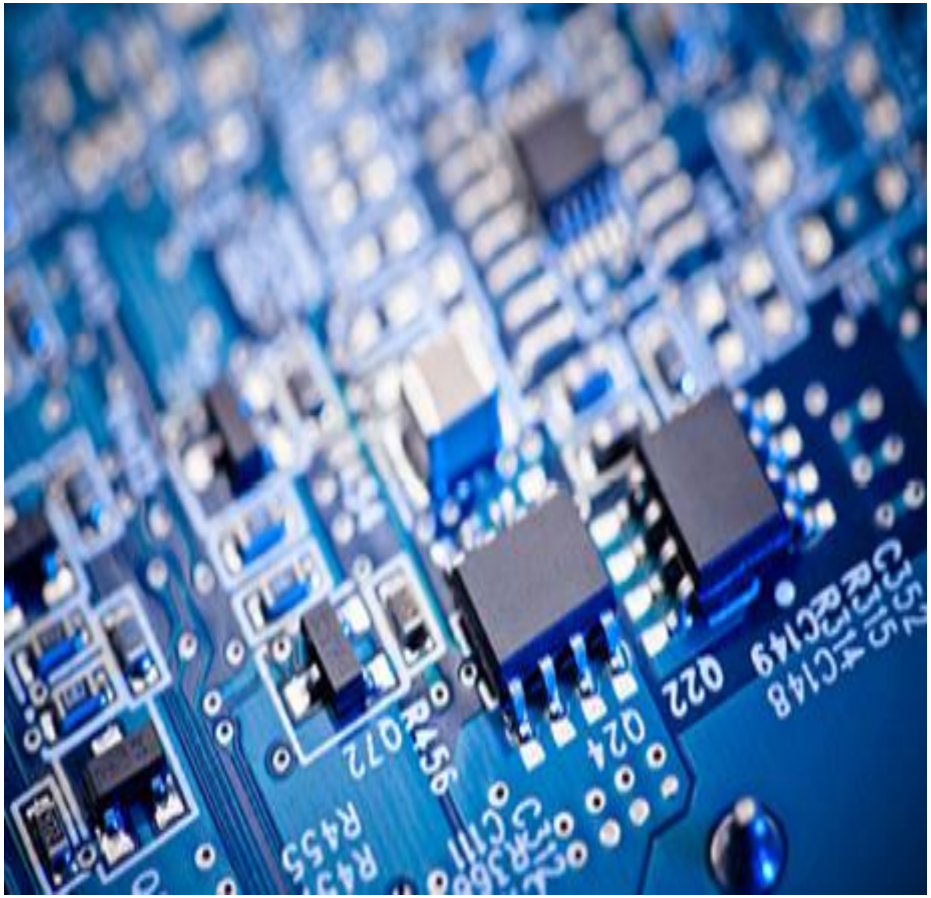
then: $I(X;Y)=I(X,Y)=H(X)=H(Y)$ i.e. total information is transmitted

Independent pair: $H(X|Y)=H(X)$

then: $I(X;Y)=H(X)-H(X)=0$ i.e. no information is transmitted

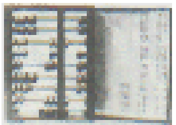
Error free encoding is possible if: $H(X) \leq C$

HARDWARE

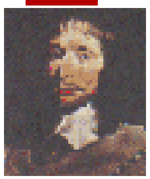


- History
- Boolen’s World
- Neuman Machine
- Modern Machine
- Networking Basics

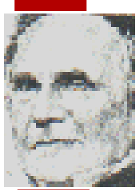
Hardware: a short history



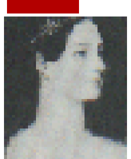
i.e.1000
Abacus



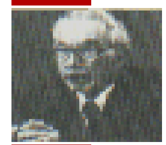
1642
Blaise PASCAL
mechanical computing machine



1833
Charles BABBAGE
Lady Ada LOVELACE
Lord Byron lánya
punch card system



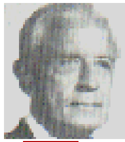
1937
Howard AIKEN Harvard
electromechanical machine Mark I.



1940's
John ATANASOFF
Clifford BERRY
John MAUCHLY
Iowa Collage
electronic machine ENIAC

John von NEUMANN
Moore School
EDVAC.

1947
William SHOCKLEY, John BARDEEN, Walter BRITTAIN
Bell Labor *tranzistor*



1951
Thomas WATSON
IBM *UNIVAC1 for General Electric*

1963 John KEMENY
Dartmouth College
BASIC

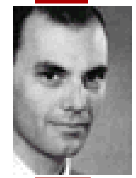
1971 Ted HOFF, INTEL
mikroprocessor.

1975 Steven JOBS,
APPLE *PC*

1976 Billy GATES,
Microsoft *DOS op.sys*

1969 Jack and Laura
DANGERMOND
ESRI GIS

1964 Paul BARAN
Packet SwitchingTech.

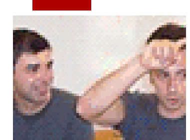


1966-69
Larry ROBERTS, *ARPA*

1974 Vint CERF,
ARPANET *TCP/IP*

1990 Tim BERNERS-LEE,
Cern *World Wide Web*

1994 David FILO and
Jerry YANG *YAHOO!*



1998 Larry Page and
Sergey Brin *Google*

Hardware: Boolen’s binary world

John Boole
(1815-1864)

A	B	A ∧ B
1	1	1
1	0	0
0	1	0
0	0	0

AND

A	B	A ∨ B
1	1	1
1	0	1
0	1	1
0	0	0

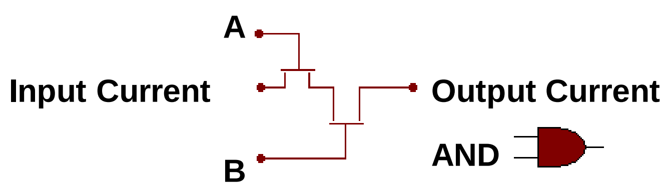
OR

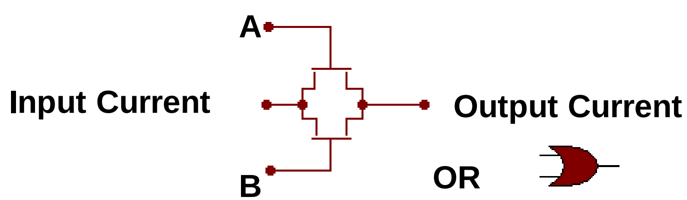
A	¬A
1	0
0	1

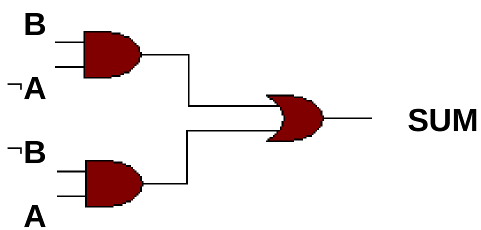
NEGAT

13=			1	1	0	1
+22=		1	0	1	1	0
35=	1	0	0	0	1	1

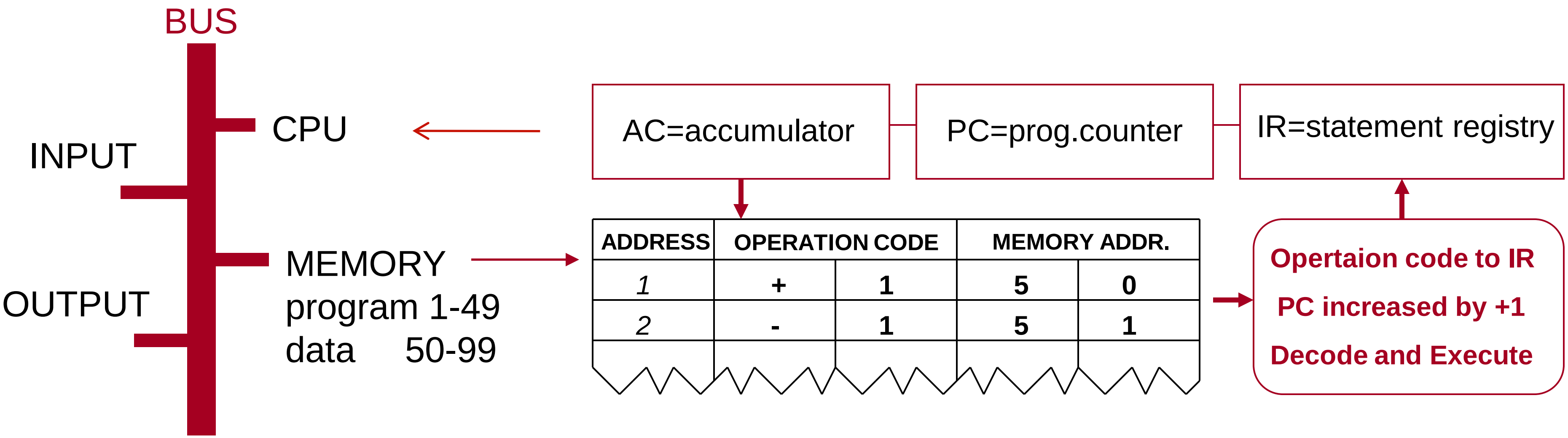
SUM= $(\neg A \wedge B) \vee (A \wedge \neg B)$







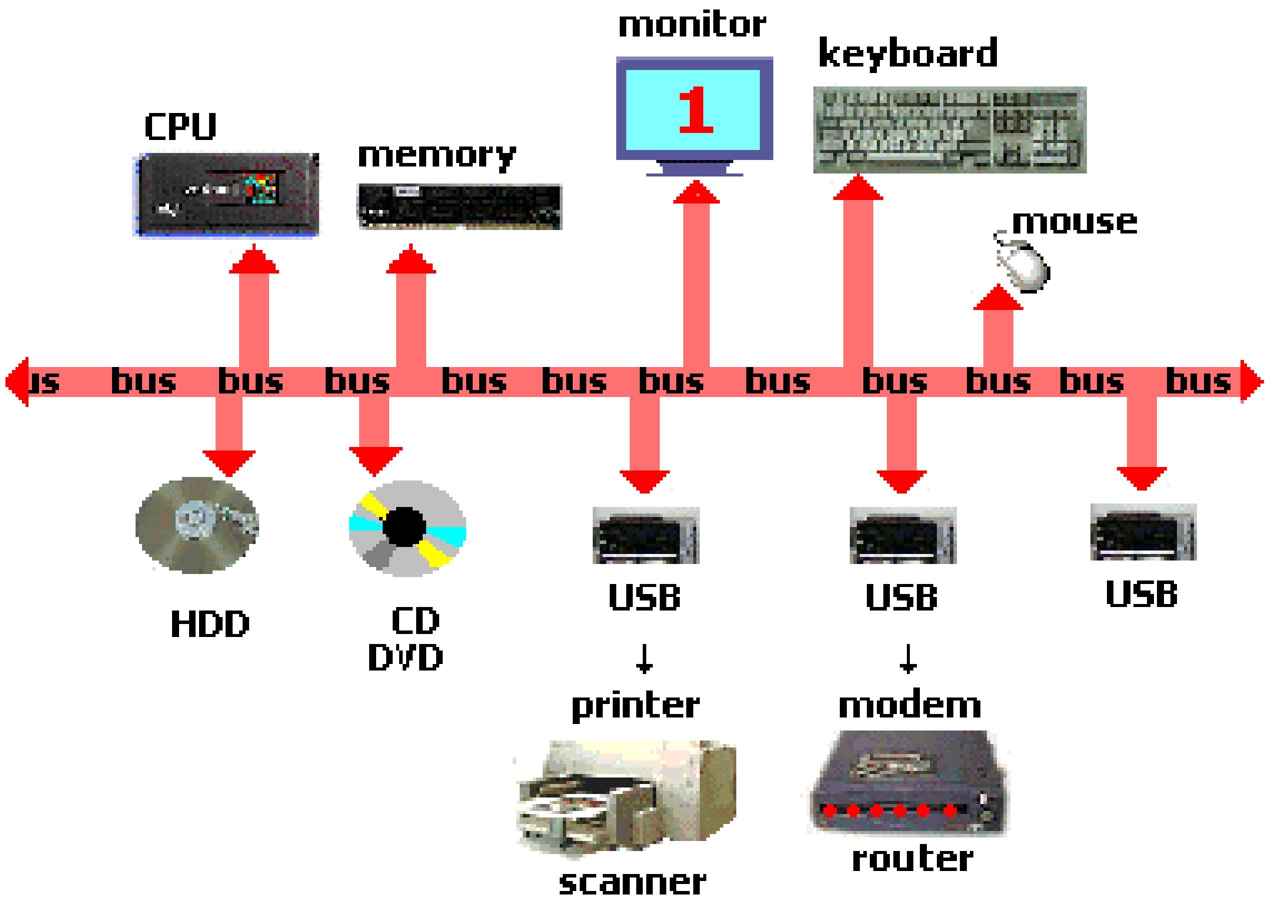
Hardware:Neumann machine



John Von Neumann (1903-1957)

CODE	ADDITION OF TWO NUMBERS		OPERATION CODES
+150	INPUT	load a number to address 50	1 = INPUT
+151	INPUT	load a number to address 51	2 = OUTPUT
+350	LOAD	load content 50 to AC	3 = LOAD
+551	ADD	add content 51 to number in AC	4 = STORE
+452	STORE	store content AC to address 52	5 = ADD
+252	OUTPUT	output content 52	6 = SUBSTRACT
+700	HALT	stop program	7 = HALT

Hardware:Modern machine



Parameters of a modern machine

Operational speed
Hz = 1/sec

Data storage
Bit

Motherboard and chipset,

VideoCard

Periferies

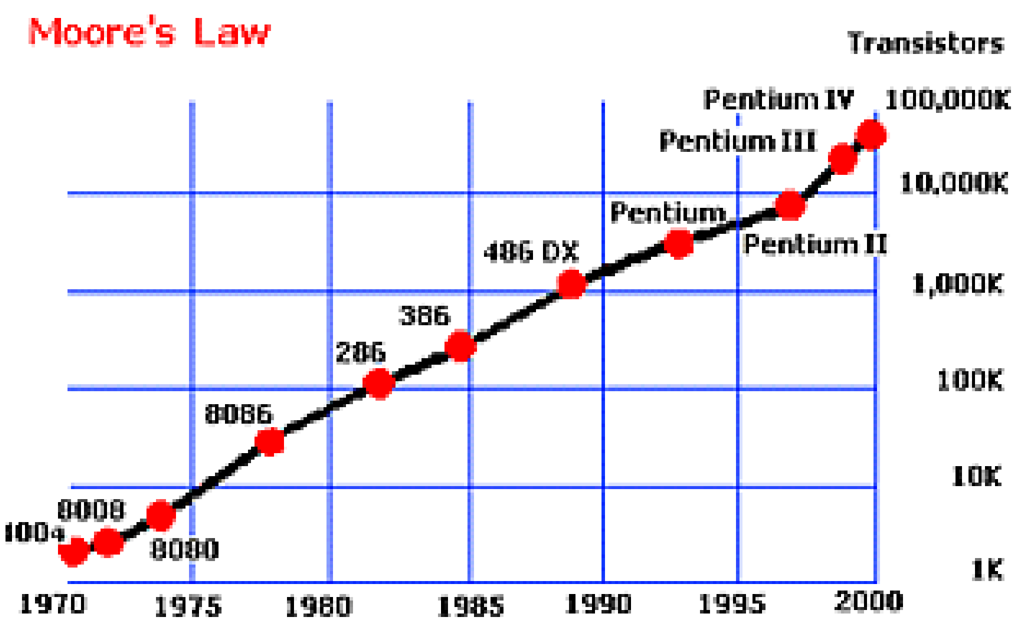
Processor


Ted Hoff (1937 -)

Clock: time period of 1 fetch-execute cycle in Hz=1/sec

Cache memory: L1 (128 Kb) CPU integrated in CPU
L2 (Mb) Direct connnected to CPU

Parallel handled bits



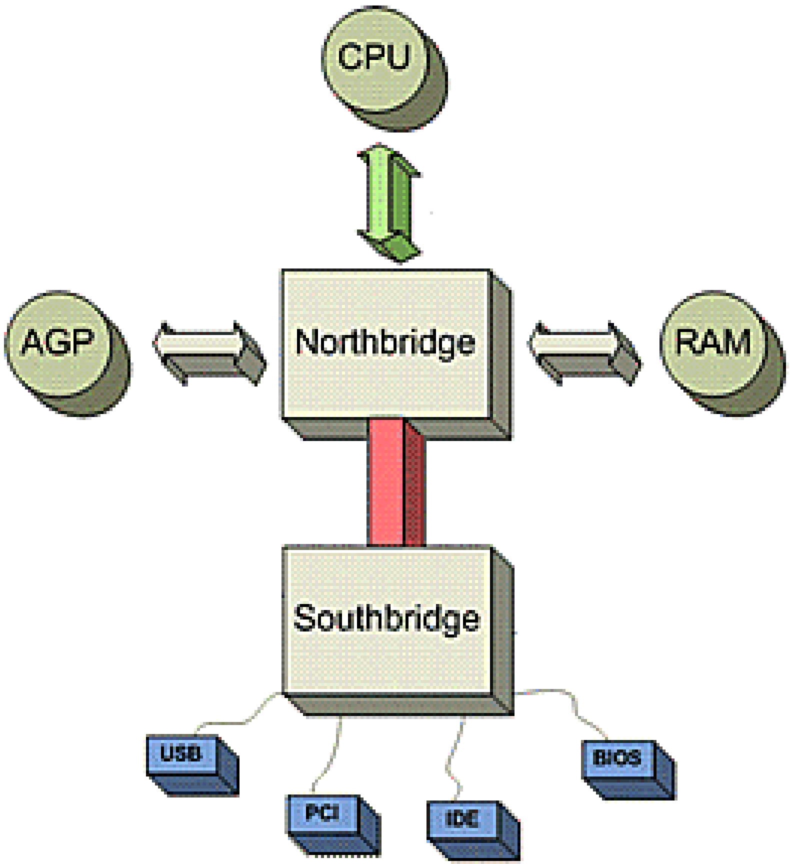
Processor producers:

Intel Corporation
Advanced Micro Devices
Motorola Corporation

Exponential grow of powere – doubled every 18 months

Generation I-VII	Year	Data/ Address bus	L1 Cache (KB)	Memory bus speed (MHz)	Internal clock speed (MHz)
8088/ I.	1979	8/20 bit	None	4.77-8	4.77-8
8086/ I.	1978	16/20 bit	None	4.77-8	4.77-8
80286/ II.	1982	16/24 bit	None	6-20	6-20
80386DX/ III.	1985	32/32 bit	None	16-33	16-33
80386SX/ III.	1988	16/32 bit	8	16-33	16-33
80486DX/ IV.	1989	32/32 bit	8	25-50	25-50
80486SX/ IV.	1989	32/32 bit	8	25-50	25-50
80486DX2/ IV.	1992	32/32 bit	8	25-40	50-80
80486DX4/ IV.	1994	32/32 bit	8+8	25-40	75-120
Pentium/ V.	1993	64/32 bit	8+8	60-66	60-200
Pent.MMX/V.	1997	64/32 bit	16+16	66	166-233
Pent.Pro/VI.	1995	64/36 bit	8+8	66	150-200
PentiumII/VI.	1997	64/36 bit	16+16	66	233-300
PentiumII/VI.	1998	64/36 bit	16+16	66/100	300-450
PentiumIII/VI.	1999	64/36 bit	16+16	100	450-1.2GHz
Pentium4/VII.	2000	64/36 bit	12+8	400	1.4GHz-2.2GHz
Athlon/VII.	1999	64/36 bit	64+64	266	500-1.67GHz

Chipset



Motherboard

CPU (Central Processing Unit)
RAM (Random Access Memory)
AGP (Accelereted Graphic Port)

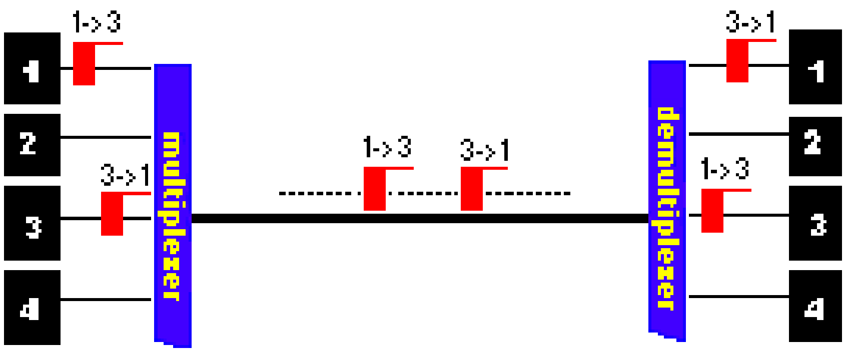
PCI (Peripherial Component Interconnect
input-output connections)
IDE (Integrated Drive Electronics
HDD, CD, DVD connections)
USB (Universal Serial Bus
soros hardware connections)
BIOS (Basic Input/Output System
basic op.sys program stored in
EPROM processor tárol)

EPROM (Erasable Programmable Read-Only Memory processor keeps information without power

Hardware: Hálózatok

OSI - Open System Interconnection

1. Physical layer
(Ethernet; RF)
2. Network/Transport layer
(SMB, Novel, TCP/IP);
3. Application layer
(email, ftp, web).



INTERNET

PST Packet Switching Technology;
TCP/IP Network/Transport;
Client/Server Computing;
IP Number host addressing;
DNS Domain Name System ;
URL Uniform Resource Locator;

SOFTWARE

Algorithm

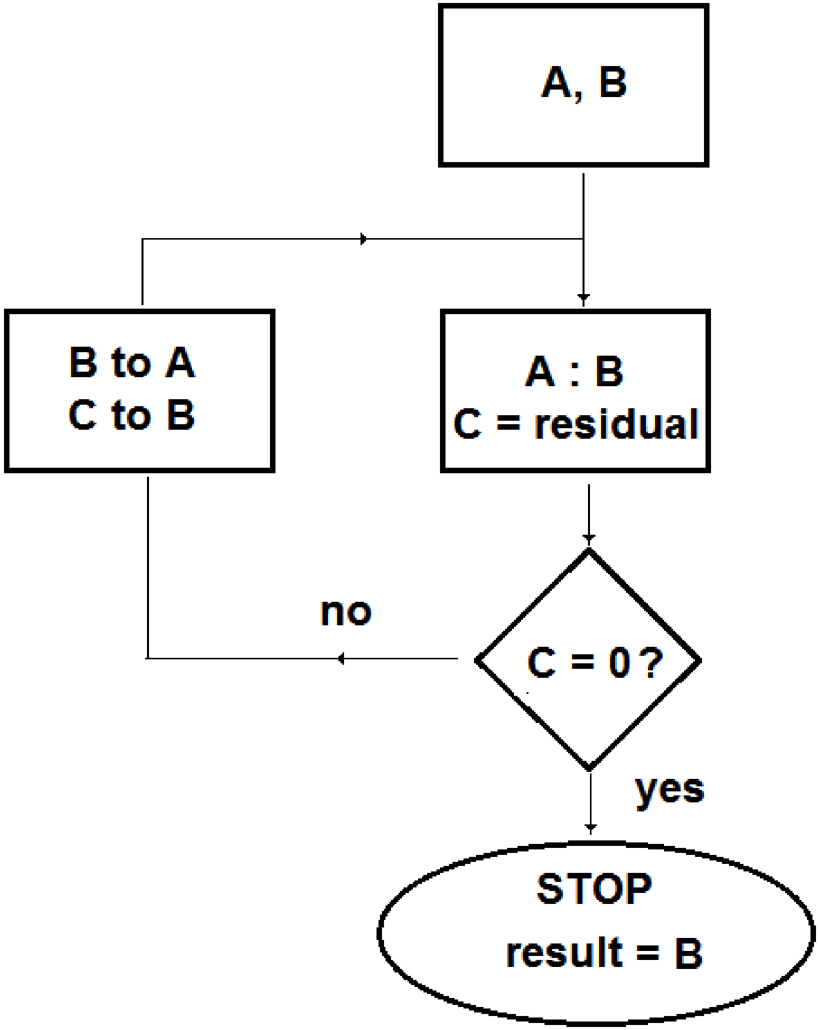
Turing Machine

Types

Levels

Styles

Software: Algorithm and Computer Program



Algorithm: systematically repeated process in limited steps to solve a problem

Computer Program: one or more algorithm described for computers

Algorithm Example: calculating the highest common factor of two numbers *(Euclid's algorithm)*

Software: Turing gép

David Hilbert (1862-1943) *Entscheidungsproblem (decision problem)* is there at least one algorithm for every problem to solve?

Alan Turing (1912-1954) created a theoretical *Universal Computing Machine* that can simulate virtually any algorithm. He proved with the machine that there is algorithm which can not stop in finite steps (halt problem).

Kurt Gödel (1906-1978)
If arithmetic operations are included in a mathematical system, the system must have statements that can be neither proved nor disproved.

Software: Program Types

- **operating systems** (Windows, Linux, UNIX, MacOS etc.)

- **developing systems** - IDE (Intelligent Developing Environment - Visual BASIC, C++, JAVA, DELPHI etc.)

- **applications** (text, sreadsheet, database, image processing communications, games, technical and scientific, special applications)

Software: Program Levels

Level	Description	Examples
Machine Code	Direct processor control – effective, fast but NOT user friendly	Assembly
Compilation Languages	Machine code program parts are included in English terms called statements. They provide easier but lengthy programming process	FORTRAN, PASCAL, JAVA
Interpretating Languages	They are similar to the compilation languages, but they contain real time error filtering and compilation (IDE-Intelligent Developing Environment).	BASIC, VisualBASIC, PROLOG stb.

Software: Program Styles

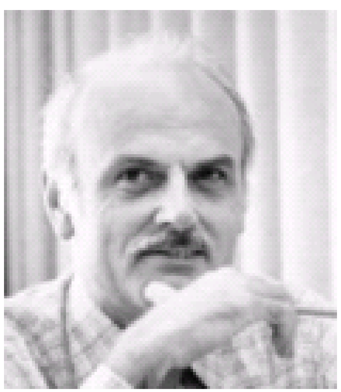
Style	Description	Examples
Imprative Languages	The program is a sequence of statements. The input data are stored in variables and the variables are manipulated with the statements..	BASIC, FORTRAN, PASCAL, PERL
Logical (predicative) Languages	The program is a sequence oh of testin hypothesis using statements and rules.	PROLOG, LISP, SmallTalk
Object-Oriented Languages	The data and attributums of a problem are connected to an object in hierarchical order.	HTML, JavaScript, Java, Visual Basic, C++.

4. DIGITAL PICTURES AND DATABASES

William Fetter
(1928-2002)

<u>Computer Graphics</u>

- displaying and storing pictures
- image processing
- applications



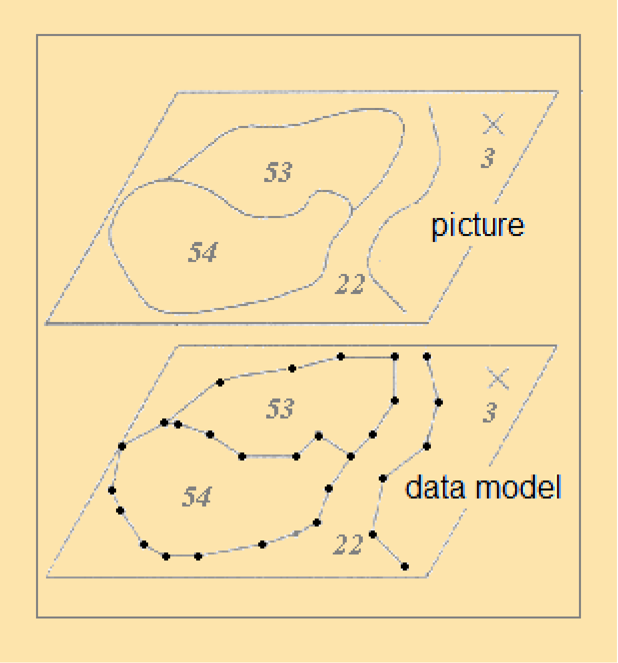
Edgar Frank Codd
(1923-2003)

<u>Digital Databases</u>

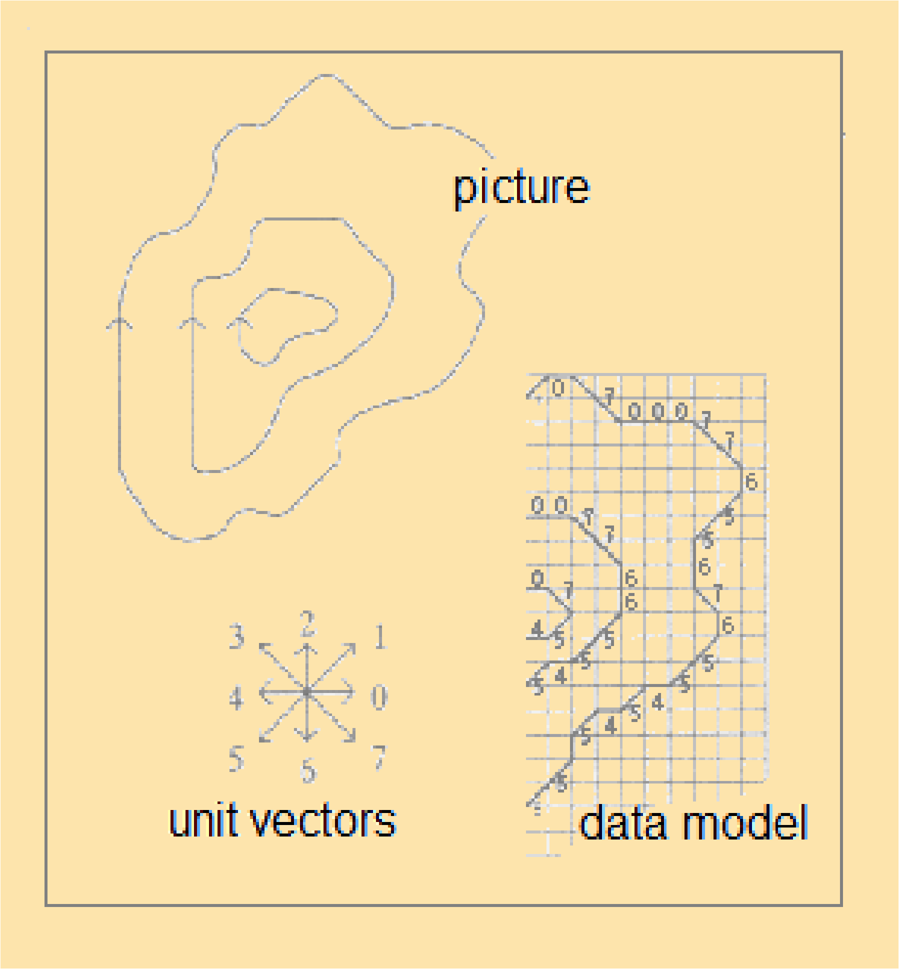
- database types,
- relational database and SQL
- examples

Vectorial technics: Spagetti Model

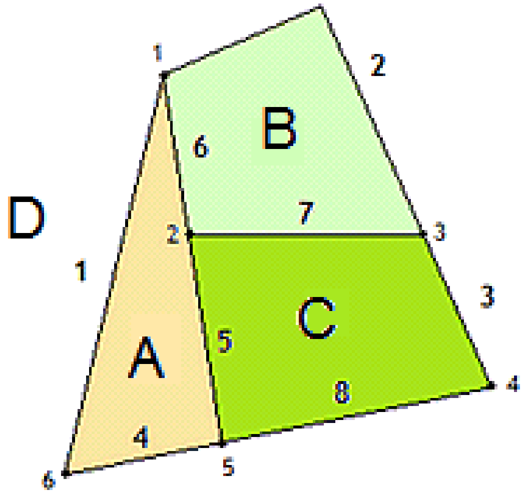
Element	Code	Coordinate
Point	3	x,y
Line	22	x1,y1, x2,y2 ...
Poligon	53	x1,y1, x2,y2 ...
	54	x1,y1, x2,y2 ...



Vektorial technics: Chain Model

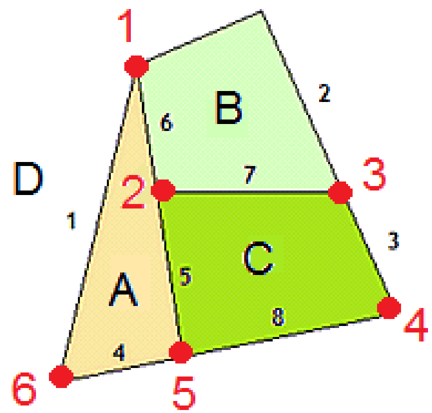


Vektorial technics: Topologic Model 1.



Poligon	Line
A	1,4,5,6
B	2,6,7
C	5,7,3,8
D	1,2,3,8,4

Line	Poligon
1	D-A
2	D-B
3	D-C
4	D-A
5	A-C
6	A-B
7	B-C
8	D-C



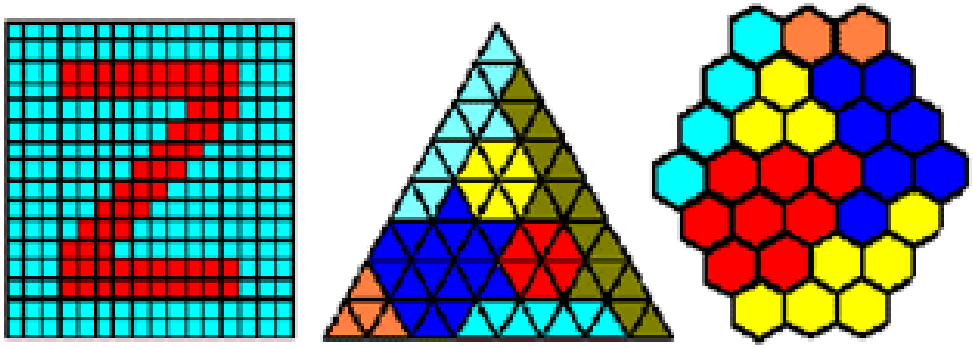
Vectorial technics: Model 2.

Line	Point
1	6-1
2	1-3
3	3-4
4	5-6
5	2-5
6	1-2
7	2-3
8	4-5

Line	Coordinate
1	x6y6-x1y1
2	x1y1-x3y3
3	x3y3-x4y4
4	x5y5-x6y6
5	x2y2-x5y5
6	x1y1-x2y2
7	x2y2-x3y3
8	x4y4-x5y5

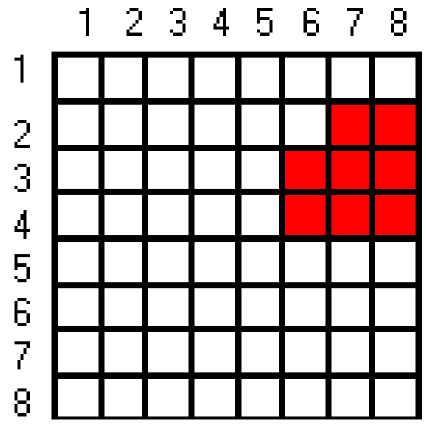
Start Point	Line	End Point
1	1 6 2	6 2 3
2	5 7	3 5
3	3 7	4 2
4	3 8	3 5
5	8 5 4	4 2 6
6	4 1	5 1

Raster technics



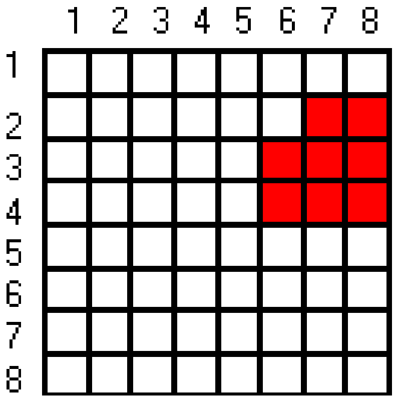
Raster technics: Bitmap Model

00000000000000110000011100000111
plus 4x8=32 zeros.



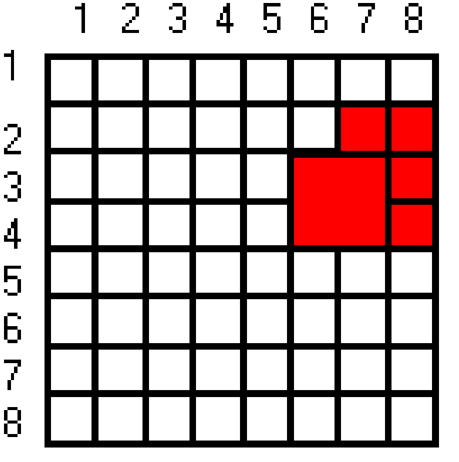
Raster technics: Row-Expansion Model

Sor	2	3	4
Oszlop	7,8	6,8	6,8



Raster technics: Axis-Transformation Modell

2,7,1 2,8,1 3,6,4 3,8,1 4,8,1

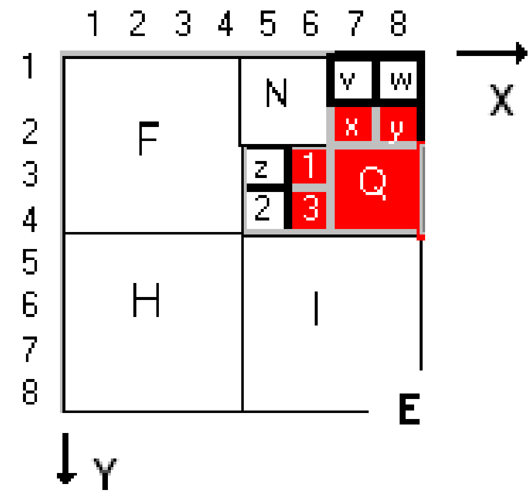


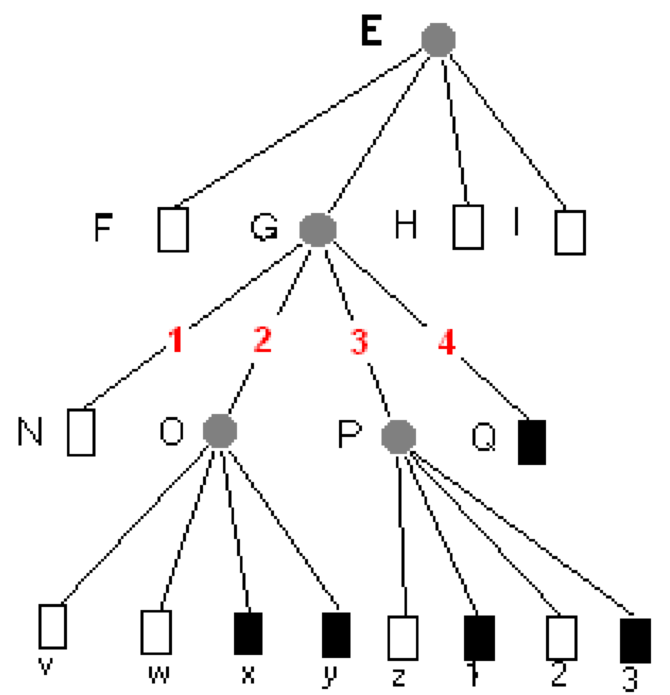
Raster technics: Quadratic-Graph (Scantling)

$$x = \sum_{i=2}^{h} = x(i) \quad (\text{ ha } l(i)=2,3 \Rightarrow x(i)=2^{m-h+1} \quad \text{otherwise} \quad x(i)=0\ )$$

$$y = \sum_{i=2}^{h} = y(i) \quad (\text{ ha } l(i)=1,2 \Rightarrow y(i)=2^{m-h+1} \quad \text{otherwise} \quad y(i)=0\ )$$

coordinates of upper left corners
of the squares





Raster Pictures

Exten-sion	Name	Program	Comp-ression	Trans-parency	Ani-mation
bmp	Windows Bitmap	Windows	no	yes	no
jpeg	Joint Photographic ExpertsGroup	Windows	yes	no	no
tiff	Tagged Image File	Windows	yes	yes	no
png	Portable Network Graphics	Windows	yes	yes	no
gif	Graphics Interchange Format	Windows	yes	yes	yes
img	ERDAS IMAGINE	ERDAS	yes	no	no

Vector Pictures

Exten-sion	Name	Program	Comp-ression	Trans-parency	Ani-mation
cgm	Computer Graphics Metafile	-	yes	-	no
svg	Scalable Vector Graphics	-	yes	-	no
dxf	Drawing Exchange Format	CAD	yes	-	no
swf	Small Web Format	Adobe	yes	-	yes
wmf	Windows Metafile	Windows	yes	-	no
shp	ESRI shapefile	ARC	yes	-	no

Image processing: Geometric operations in vector models

Line :

$y = mx+b$ $m = (y_2-y_1)/(x_2-x_1)$ $b = mx_1+y_1$

•

•**Intersection point** *M:* solution of the next

•equation system

$y = m_{3,4}\, x + b_{3,4}$ $y = m_{2',3'}\, x + b_{2',3'}$

•**Distance between point 1 and 2**

$s_{1,2} = [\, (x_2-x_1)^2+(y_2-y_1)^2\,]^{1/2}$

•**Angle between line1-2 and 1-2**'

•$a = arctg\, (m_{1,2}) - arctg\, (m_{1,2'})$

•

•**Circumference of square 1-2-3-4**

•$K = s_{1,2} + s_{2,3} + s_{3,4} + s_{4,1}$

•**Area of square** 1-2-3-4

$T = T_{1,2,3\ háromszög} + T_{1,3,4\ háromszög}$

•**Centre of square 1-2-3-4**

$x_s = (\, x_1 + x_2 + x_3 + x_4\,) / 4$

$y_s = (\, y_1 + y_2 + y_3 + y_4\,) / 4$

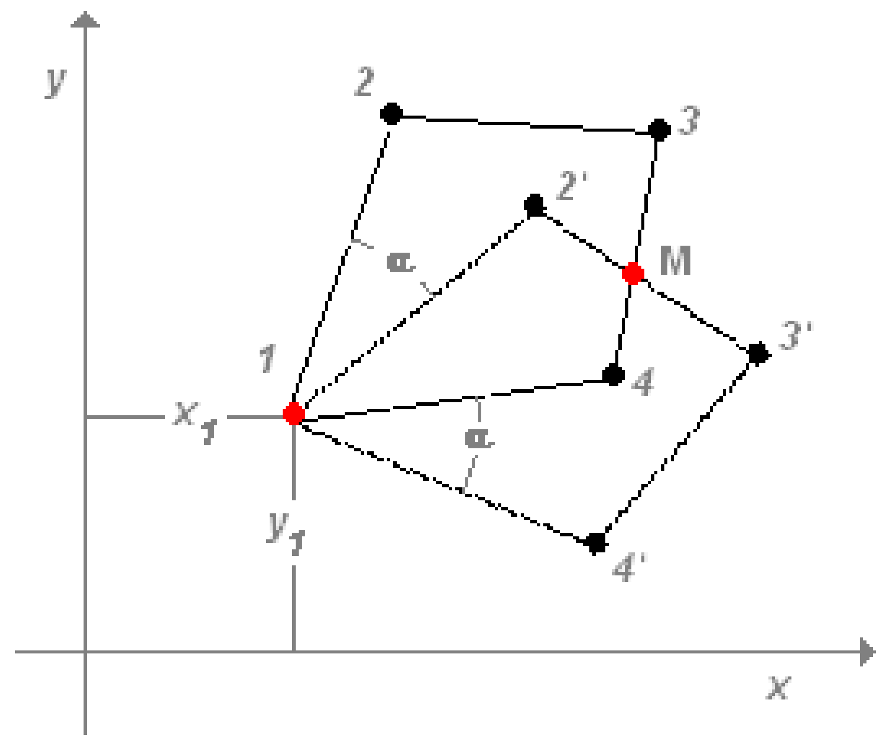
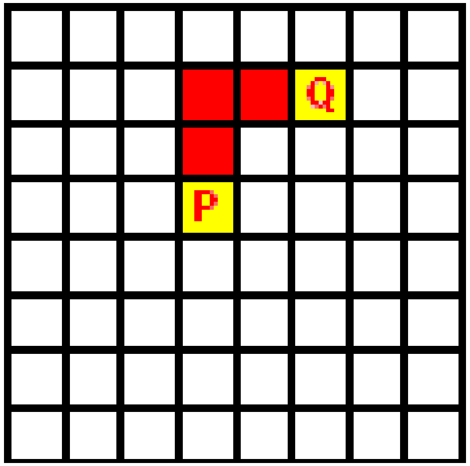
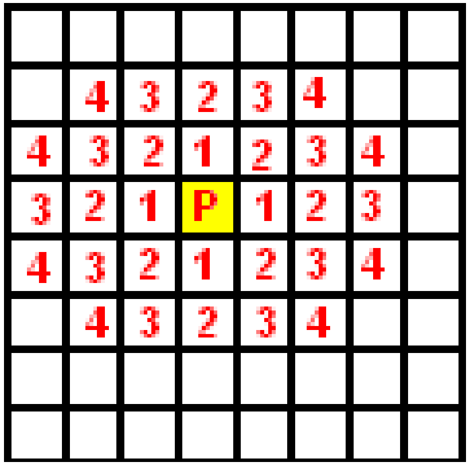


Image processing: Geometric operations in raster models

discrete geometric operation
with Manhattan distance





P-Q Manhattan distance = 4

Image processing: False color technique in raster models

Concurent shot to a spot with cameras sensitive for frequency of Red (R), Green (G) and Blue (B) light. The pictures are mounted above each other. Depending on the ratio of the colors in the composite different objects can be stressed.

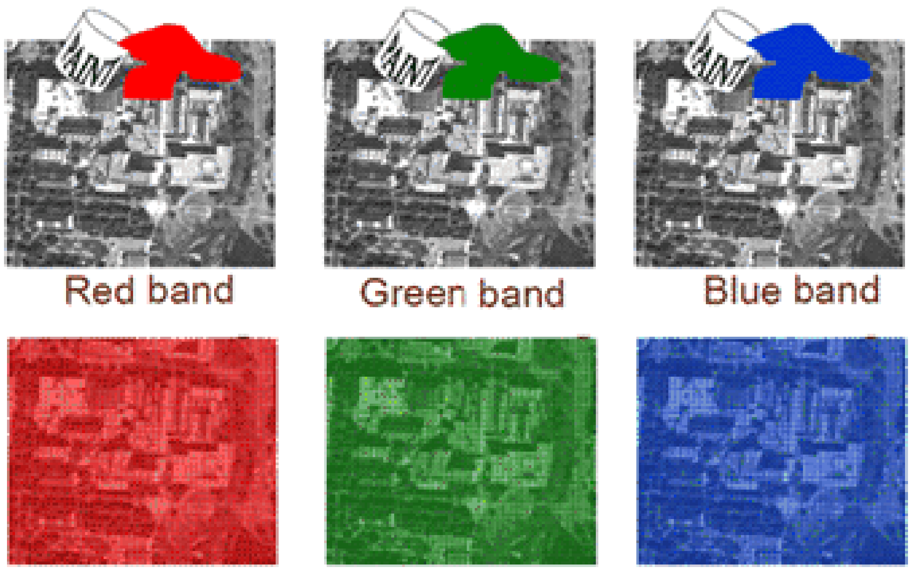


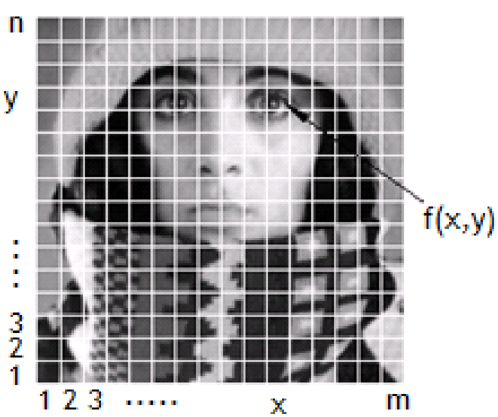
Image processing: Identification of objects in raster models

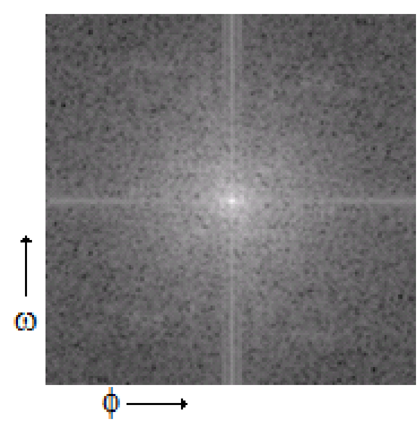
$$F(\omega,\phi) = \sum_{x=-\infty}^{\infty} \sum_{y=-\infty}^{\infty} f(x,y)\; e^{-j(x\omega + y\phi)} \qquad e^{-jq} = \cos(q) - j\sin(q)$$

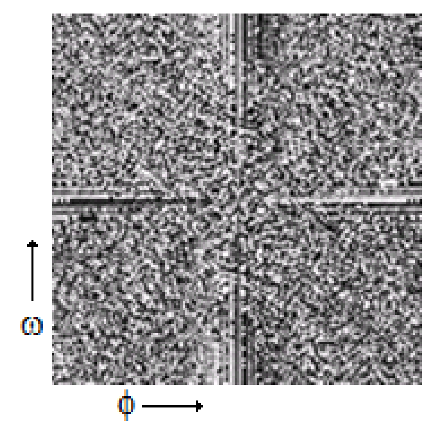
$$F(\omega,\phi) = \sum_{x=-\infty}^{\infty} \sum_{y=-\infty}^{\infty} f(x,y)\cos(x\omega+y\phi) - j\, f(x,y)\sin(x\omega+y\phi)$$

space domain

frequency domain

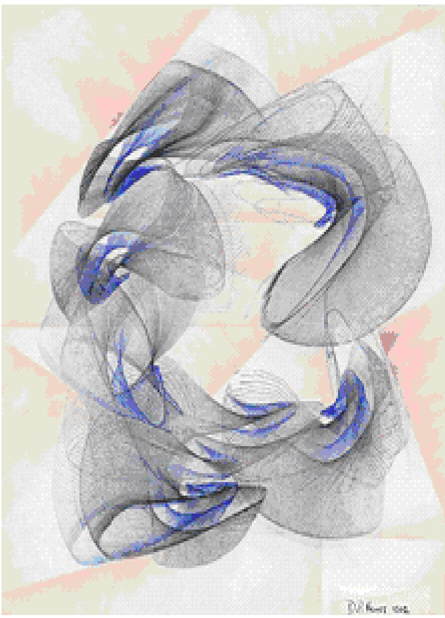




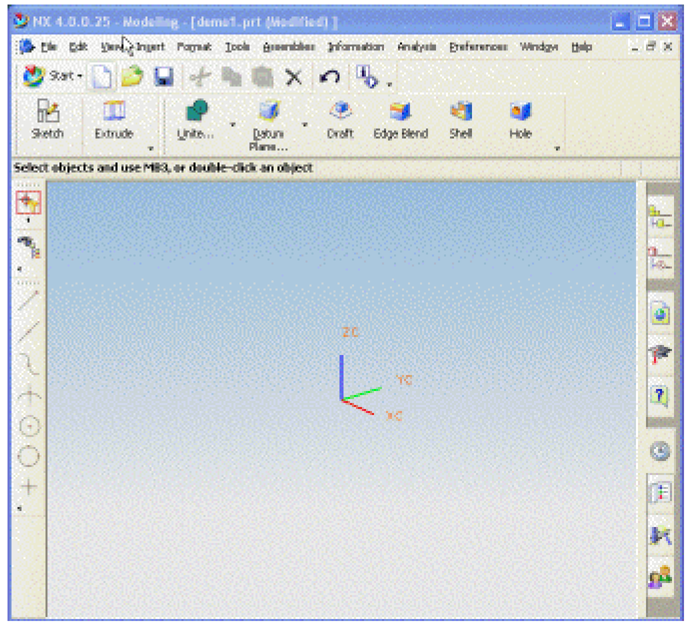


$f(x,y)$ amplitude $\{F(\omega,\phi)\}$ phase $\{F(\omega,\phi)\}$

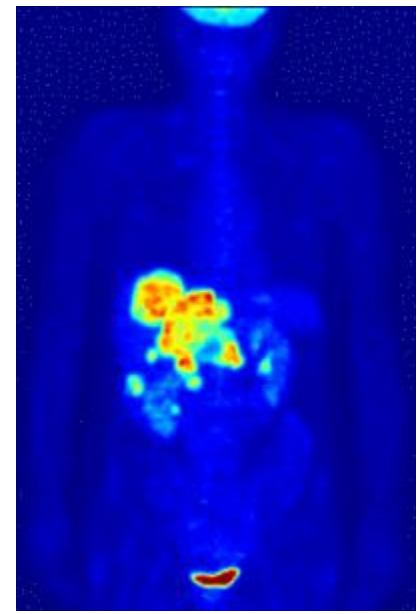
Application: Art, Computer Aided Design (CAD), Medicine



D.P Henry (1962)
Computer graphics

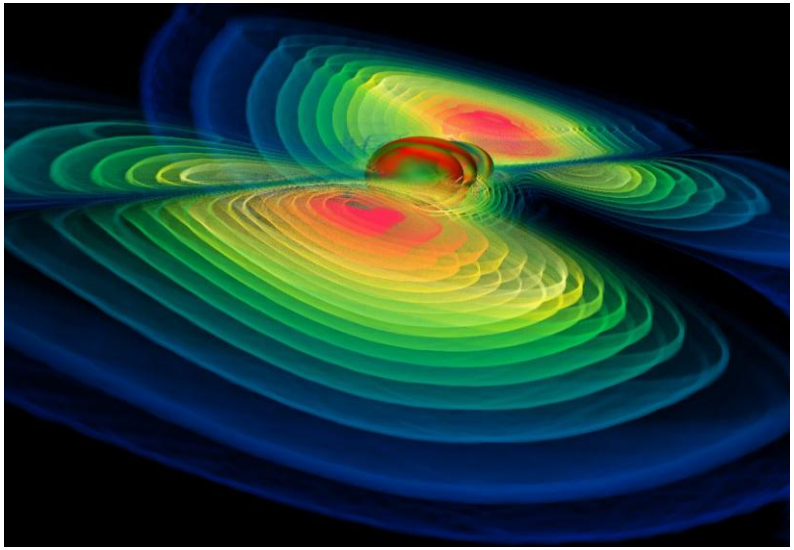


CAD



PET
Positron Emission Tomography

Application: Science, Virtual Reality

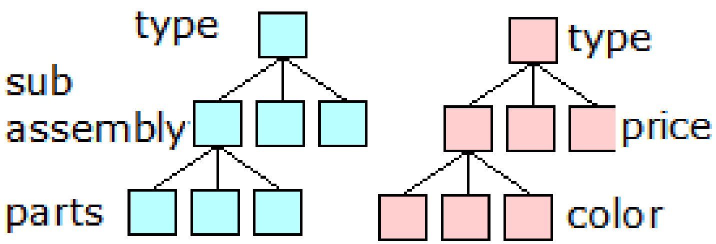


Gravitation waves

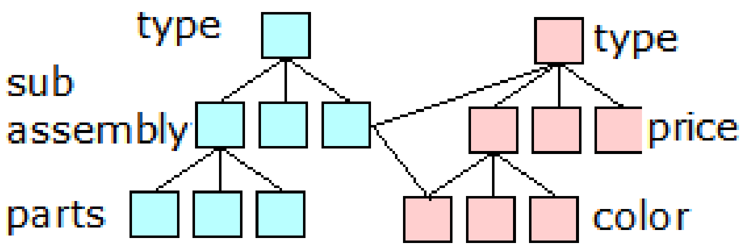
Parachuter training

Digital DataBase: Concept and Types

The digital DataBase is a collection of data stored in a regulated structure and controlled by a program called Database Management System (DBMS) DataBase types are as follows:



1. Hierarchical model   1:n

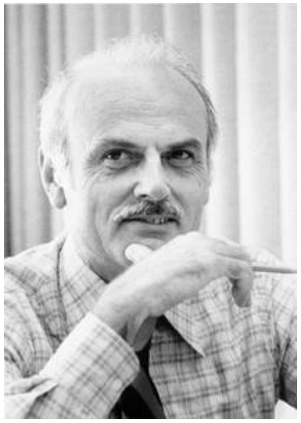


2. Network model m:n

3. Relational model m:n
data are structured in tables related to each other.

4. Object oriented model m:n
structure is organized in objects

Concept of Relational DataBase



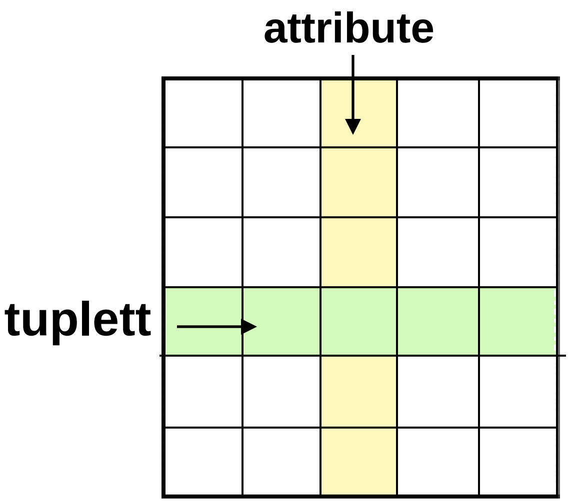
Edgar F.Codd

The properties of entities can be structured in tables where the columns are the properties (called as attributes) while the rows are the groups (called as tupletts) of attributes belong to an entity. High priority belongs to those columns where every data is different because they are used asfor identificators in a table.

Features of Relational DataBases

- The properties of entities are structured in **tables**
- Tables consist of **attributes** and **tupletts**
- Tables can be **connected**
- **Indexing technics** is used for data identification in stoagenikát
- **Entity-Relation** data structure is applied
- Retrieval is carried out by **SQL (Structured Querry Language)**

Elements of Relational DataBase



R(A1,...,Am) relation scheme

Key of scheme **R(A1,...,Am)** is attribute **Aj(a1, a2,...an)** in that there is no identical elements.

Primary Key: a selected key

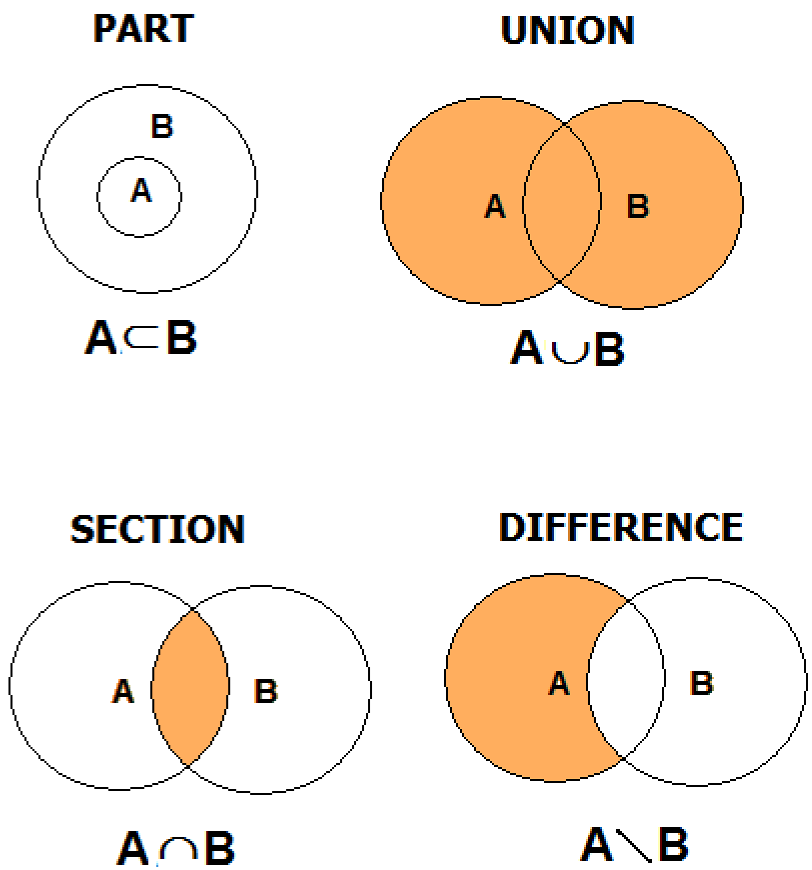
Foreign Key is a key in the referring table what will be the primary key in the referred table

First Normal Form is a scheme having primary key

Second Normal Form every attribute depends on the primary key

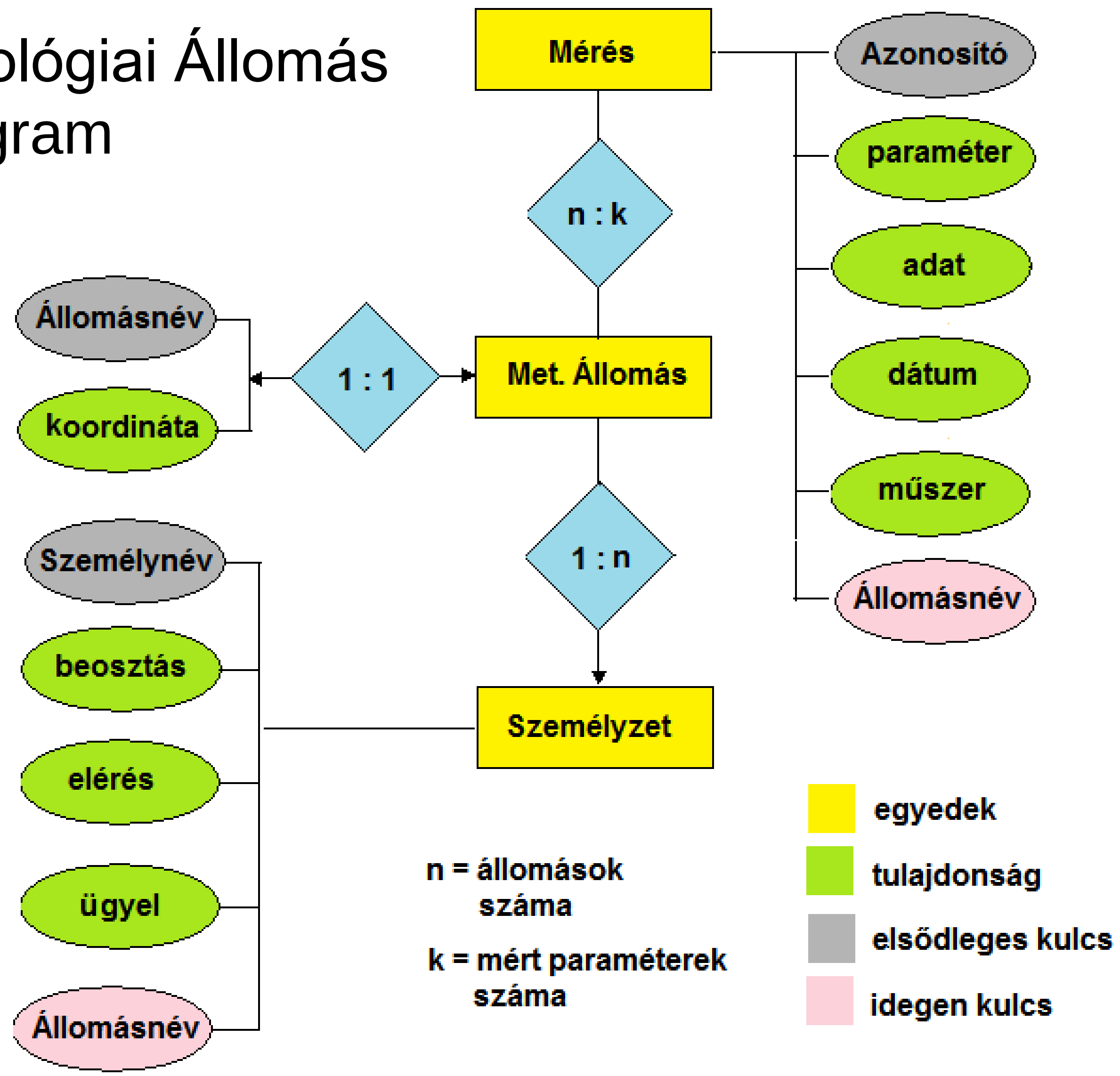
Third Normal Form the not primary keys are independent from each other

SQL (Structured Query Language) grounded on set theory



SQL	SET
RENAME(a,b)	-
RESTRICT(a:F)	part
PROJECT(a_i..)	part
UNIO(A:B)	union
INTERSECT(A:B)	section
DIFFERENCE(A:B)	difference

Meteorológiai Állomás
ER diagram



Meteorológiai Állomás táblázatai

1. Met.Állomás
2. Személyzet
3. Mérés

1

Állomás neve	Földrajzi Koordináták (hosszúság,szélesség,magasság)
Pereces	47.57834, 17.32451, 311
Árpa	47.54623, 17.45653, 223
Kisfalu	47.55231, 17.41257, 201

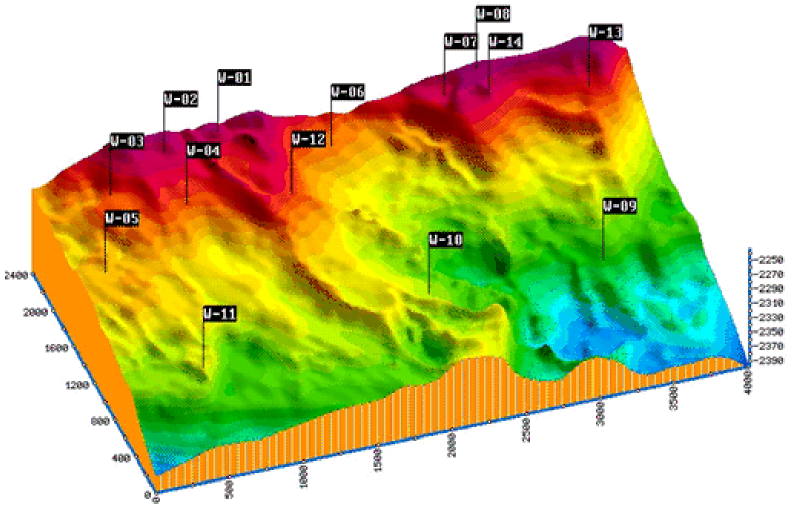
2

Név 1	Beosztás	Elérés	Ügyel	Állomás neve
Nagy J.	Tud.sm	1042341	H,SZ,P	Pereces
Szabó Z.	Technikus	1023562	K,CS,Sz,V	Pereces
Kovács I.	Tud.munk	2234716	H,SZ,P	Árpa
Maklai L.	Technikus	1287654	K,CS,Sz,V	Árpa
Körösi G.	Tud.sm	2246523	H,SZ,P	Kisfalu
Alpár T.	Technikus	1342678	K,CS,Sz,V	Kisfalu

3

Azonosító	Paraméter	Adat	Dátum	Műszer	Állomás neve
1	Hőmérséklet ^oC	23,2	14.09.16	Thermo-211	Pereces
2	Nyomás Hgmm	755	14.09.16	Pascal-MO	Pereces
3	Hőmérséklet ^oC	23,8	14.09.16	Thermo-211	Árpa
4	Pára tartalom %	54	14.09.16	Vapor-X1	Pereces
5	Hőmérséklet ^oC	22,9	14.09.16	Thermo-212	Kisfalu
6	Nyomás Hgmm	757	14.09.16	Pascal-NX	Kisfalu

5. GIS DATA and GIS SYSTEMS



<u>Digital data and Maps</u>
- digitalization,
- satellite data,
- data acquaring

Edward Feigenbaum
(1936 -)

<u>GIS Systems</u>
- analytic systems,
- expert systems

Digital data and Maps:
producing digital maps from traditional data

1. Scanning graphic maps and - digitalization of scanned picture
2. Adjusting surface on numerical data

a. Kriege method

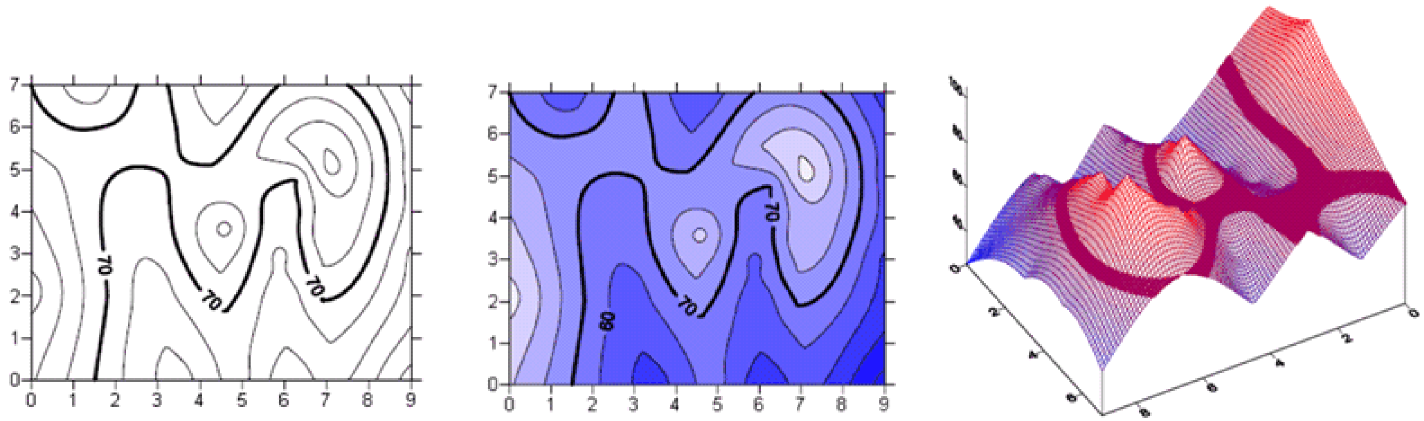
b. List square method

c. Laplace approximation

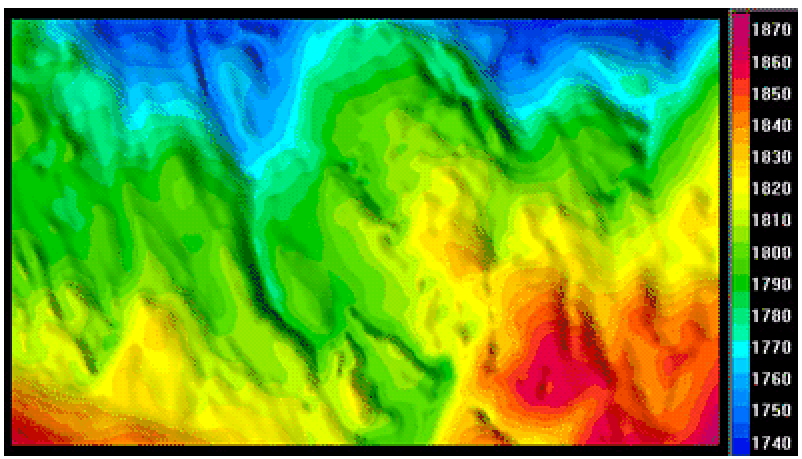
d. Finite element method: triangular tessellation – spline approximation

e. Neural networks

Digital data and Maps:
producing digital maps from traditional data



Contour and 3D maps produced by SURFER program



Contour map on the spatial distribution of the reflection time of seismic waves

Digital data and Maps:
remote sensing data and digital satellite photos

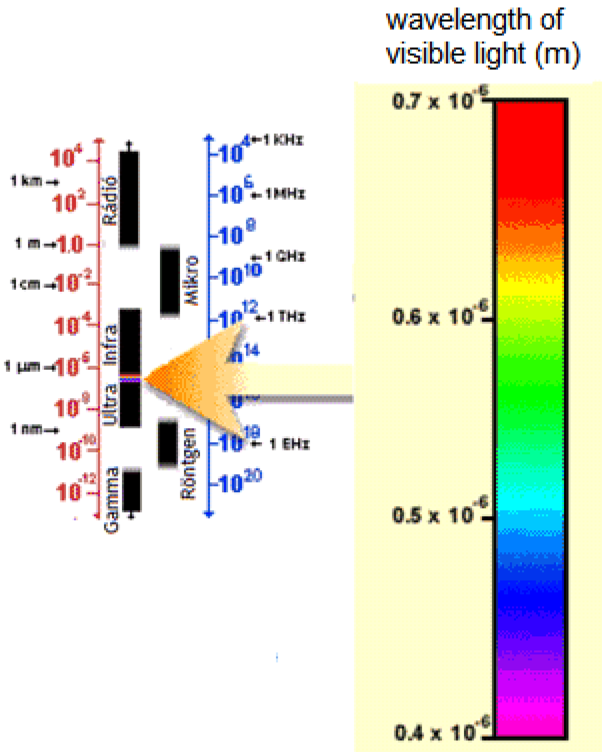


Image processing:

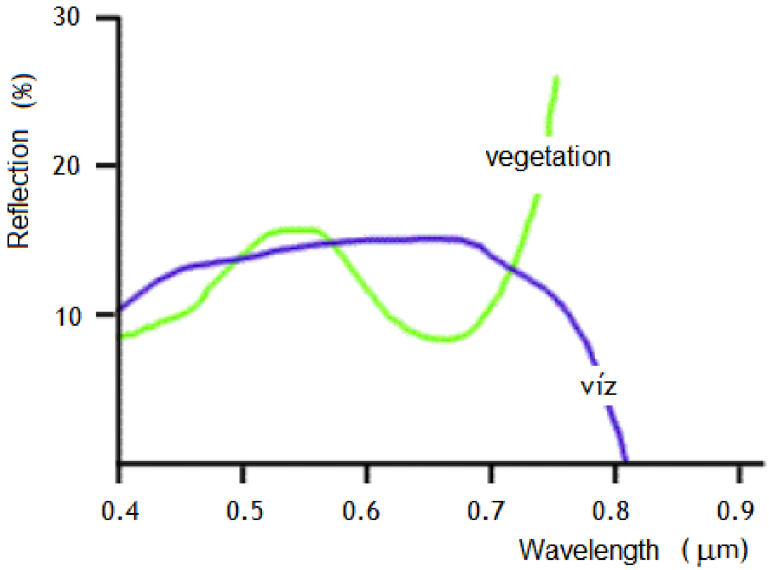
Preliminary processing
spectral: eliminating sensor errors and atmospheric effects,
geometric: coordinata transformation to geo-system

Quality improving. Contrast and lightening adjustment, filtering.

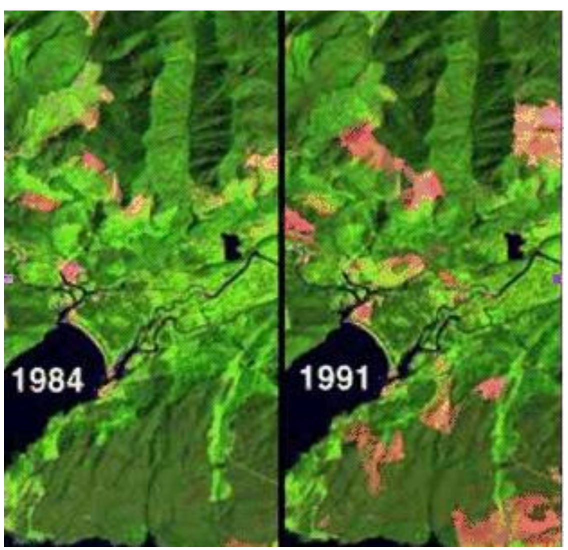
Picture transformation
Displaying details with aritmetic operation

Classification and analysis
Classification and analysis of raster pixels

Digital data and Maps: satellite sensors



Type	Wavelength	Application
TM 1	0.45-0.52 blue	Soil - Vegetation
TM 2	0.52-0.60 green	Countryside - City
TM 3	0.63-0.69 red	Countryside - City
TM 4	0.76-09 infra	Soil water content
TM 5	1.55-1.75 infra	Moisture, clouds
TM 6	10.4-12.5 infra	Termal map
TM 7	2.08-2.35 infra	Mineral map



MSS 1, 4	0.5-0.6 green
MSS 2, 5	0.6-0.7 red
MSS 3, 6	0.7-0.8 ~infra
MSS 4, 7	0.8-1.1 ~infra

TM Thematic Mapper
MSS MultiSpectral

Digital data and Maps:
Landsat,Spot,IKONOS, QuickBird satellites

	LS1	LS2	LS3	LS4	LS5	SP1	SP2	SP3	SP4	SP5	IK	QB
Launched	1972	1975	1978	1982	1984	1986	1990	1993	1998	2002	1999	2001
Height km	917	917	917	705	705	822	822	822	822	832	681	751
Returning (days)	18	18	18	16	16	26	26	26	26	16	1.5-2.9	1-3.5
Resolution m	80 80	80 80	40 80	80 30	80 30	20	20	20	20	20	4	3
Sensor	RBV MSS	RBV MSS	RBV MSS	MSS TM	MSS TM	HRV	HRV	HRV	HRV R	HRS	-	-
Bands	4 4	4 4	4 4	4 7	4 7	3	3	3	4	4	4	4

Resolution Visible (HVR)
High Resolution Visible and Infra Red (HRVIR)
High Resolution Stereo (HRS)

Digital data and Maps: acquaring data

DATA: a) geodetic data; b) thematical data

Basic Geodetic Data in Hungary

Földmérési és Távérzékelési Intézet (FÖMI) – EOV maps

1. 1:10.000 - 1:200.000 scaled topographic maps
2. DTA-10 1:10.000 scaled database (planimetric, hydrology and relief)
3. DDM digital terrain model resolution=5m
4. HGEO2000, HGGG2000 GPS-gravimety quasi-geoid, 2x2 km grid
5. CORINE - Coordination of Information on the Environment – 1:100000 scale – biophysical map

HM Térképészeti Intézet (HM TÉHI) – UTM and EOV maps

1. DTA -50, DTA -200 1:50.000 , 1:200.000 scaled UTM,EOV topographic maps
2. DDM-10 Digital Terrain Model 10x10 m
3. DDM-50 Digital Terrain Model 50x50 m

MAGYAR BÁNYÁSZATI ÉS FÖLDTANI HIVATAL
MBFH

GeoData in Hungary

Agrogeológiai adatbázisok: 179 térképi adatbázis (1931-1997)
Alapfurások adatbázisai: 243 térképi adatbázis(1952-1989)
Alap-,szerkezet földtani kutatások adatbázisai: 1846 térképi adatbázis (1908-2001)
Eötvös-inga megkutatottság adatbázisai: a 99 térképi adatbázis (1929-1965)
Építésföldtani megkutatottság adatbázisai: 1594 térképi adatbázis (1951-2001)
Ércföldtani megkutatottság adatbázisai: 620 térképi adatbázis (1930-2001)
Földmágneses megkutatottság adatbázisai: 125 térképi adatbázis (1936-1991)
Gravimetriai megkutatottság adatbázisai: 194 térképi adatbázis (1951-1991)
Környezetföldtani megkutatottság adatbázisai: 413 térképi adatbázis (1958-2001)
Nemfémes nyersanyag megkutatottság adatbázisai: 1742 térképi adatbázis (1930-2001)
Szénföldtani megkutatottság adatbázisai: 1848 térképi adatbázis (1920-1999)
Szénhidrogén megkutatottság adatbázisok: 807 térképi adatbázis(1927-2001)
Vízföldtani megkutatottság adatbázisok: 1535 térképi adatbázis (1951-2001).

US data:

US Geology Survey, Publications and Products, http://www.usgs.gov/pubprod/index.html
Global Spatial Data Infrastructure Association: http://gsdi.org/

Global data:

NASA
Federal Geospatial Data Clearinghouse Search Engine
Center for International Earth Science Information Network (CIESIN)
Central Africal Regional Program for the Environment
Digital Chart of the World Server
Data Depot's Country List
GeoBase: Canadian site for sources of free GIS data
GeoGratis: Canada's National Digital Atlas
Geoscience Australia
Gridded Population of the World

Satellite images:

Arizona Regional Image Archive (AVHRR, AVIRIS, MSS, TM, SPOT)
Canadian Geospatial Data Infrastructure
Earth Explorer (Landsat)
Earth Observing System Data Gateway)
Geoscience Australia (Free Landsat 7, MODIS & AVHRR)
Global Land Cover Facility (ASTER, Landsat, MODIS, AVHRR)
Global Visualization Viewer (Free ASTER, MODIS ,Landsat)
Landsat.org (Landsat)
NASA Image Server (Landsat 4,5,7)
Terraserver (Microsoft)
University of Nevada Landsat TM Archive
USGS EROS Data Center

GIS analytic systems

Program	**Viewer**	**Company**	**License**	**Platform**	**File-format**
ArcGIS	ArcView	ESRI	commercial	Windows/UNIX	.shx, .shp, .dbf
GeoMedia	GeoMedia Viewer	Intergraph	commercial	Windows	.csf, .map, .dbf
MapInfo	ProViewer	MapInfo Corp.	commercial	Windows	.mif, .mid
IDRISI	ProViewer	Clark Labs	commercial	Windows	.vlx, .vct, .vdc
MicroStation	Bently View	Bentley System	commercial	Windows/UNIX	.dgn, .dxf, .dwg
GRASS	QGIS	Baylor University	free	UNIX	...
SIGIS	...	SIGIS Co.	free and commercial	Windows	...
ERDAS	…	Erdas/Leica	commercial	Windows	.img
SURFER	…	GoldenSoftwer	commercial	Windows	.img

GIS analitic systems: Operations of Vector data sets

Selection of Geoobjects in a datasets for further elaboration

Vector Operations with One data set :

- Establishing zones around geoobjects;
- Displaying elements;
- Deleting elements;
- Smoothing.

Vector operations with multi data :

- Union;
- Section;
- Difference;
- Data updating from the newer set.

Network analysis from topologic vector data set

optimal route, speed etc.

Analitikus térinformatikai rendszerek: műveletek raszteres állományokon

Pixelek osztályozása,

nem felügyelt osztályozás intenzitási értékek alapján csoportosítunk
felügyelt osztályozás előre kiválasztott mintapixelek szerint csoportosítunk

Átkódolás és sorszámozás, pixelértekeket új értékkel látunk el

Zóna generálás: adott pixelektől adott távolságra zónát generálunk

Összeláthatóság: két pixelt összekötő egyenes nem metszi a terepet

Elöntési kép: magassági modelleken elöntési terület modellezhető

Vízgyűjtő területek kijelölése: magassági modelleken végezhető művelet

Vízössszefolyás: magassági modelleken végezhető művelet

Útvonal és költség analízis: optimalizálási művelet

Analitikus térinformatikai rendszerek: állomány független műveletek

Digitalizálás és adatbázis készítés: mind vektoros, mind raszteres állományban elvégezhető művelet.

Felület illesztés: mind vektoros, mind raszteres állományban elvégezhető művelet.

Modell konverziók: vektor–raszter és raszter-vektor konverziókat végző műveletek.

Fájl konverziók: különböző GIS programban készült fájlok importálása adott GIS rendszerbe, illetve az adott rendszerbe más rendszer fájl típusába történő fájl konverzió (fájl exportálás). Általában ESRI .shp, .shx, .dbf fájlokat importálnak és exportálunk, mivel ezek egyfajta, nem hivatalos szabványnak tekinthetők a térinformatikában.

Expert systems: Artificial Intelligence and Expert System

Artificial Intelligence: Information branch to develop computer applications for solving tasks claiming human intelligence. (Minsky 1985)

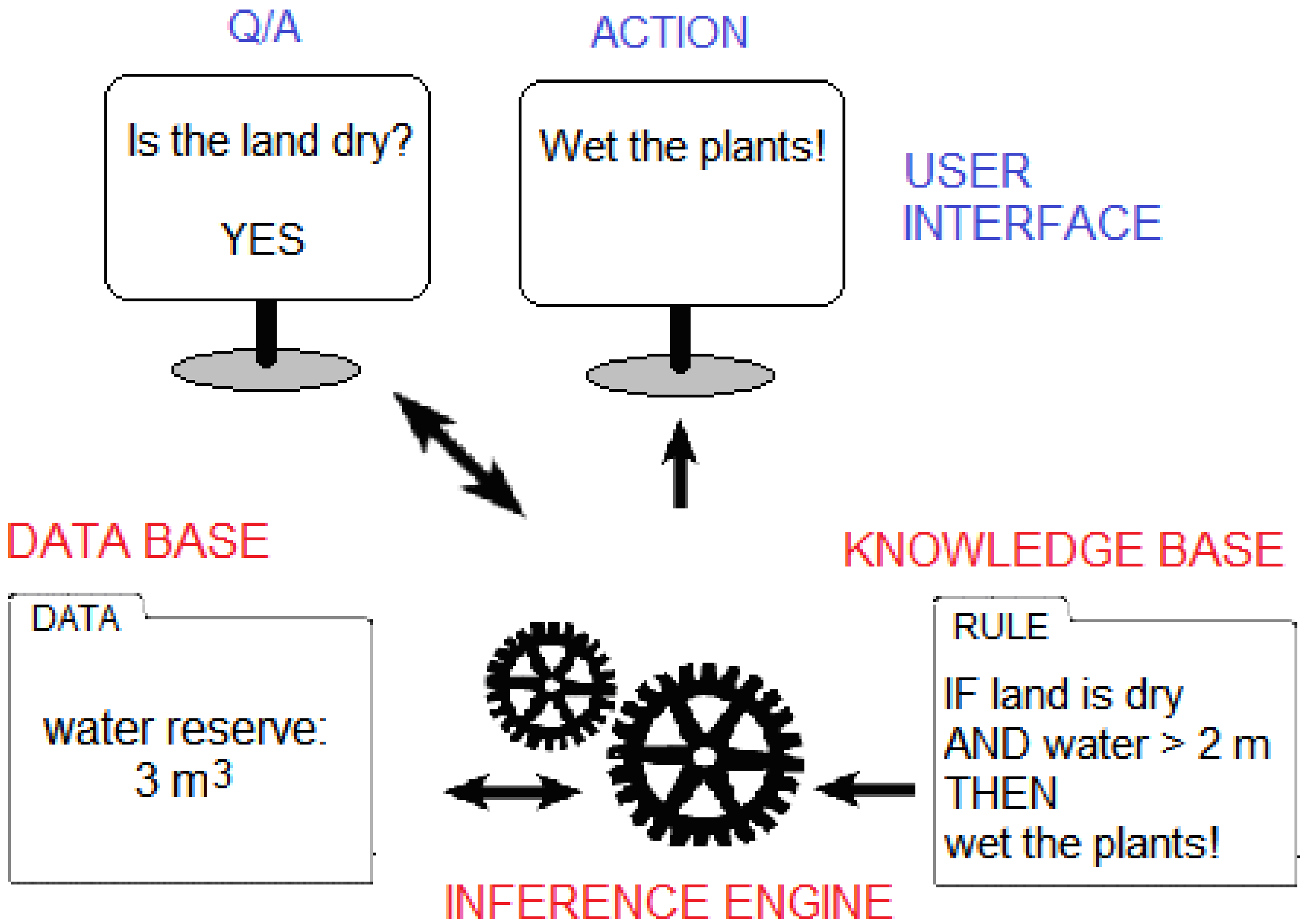
Artificial Intelligence: Information branch trying to apply computers for tasks where recently the humans are better. (Rich 1984)

Artificial Intelligence: Information branch to develop computers having features considered as expressions of human intelligence. (Barr and Feigenbaum 1982)

Artificial Intelligence: Information branch to investigate the exhibition of human intelligence. One target is to understand the human intelligence. The other goal is to create useful machines. (Garnham,1987)

Expert System ES computer program using professional knowledge and mathematical logic to solve problems claiming professional experts (Feigenbaum)

Expert System: Elements of ES



Expert System: Inference Engine

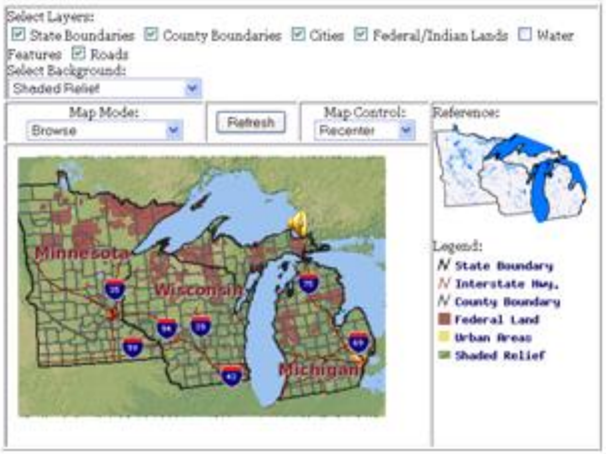
Inductive (forwrad) Inference: the conditions are given by the user and the system gives the advise for action (goal oriented search)

Input: Condition(s) → Output: Action

Deductive (backward) Inference what are those condition when an intentional action van be carried out (condition oriented search)

Input: Action → Output: Condition(s)

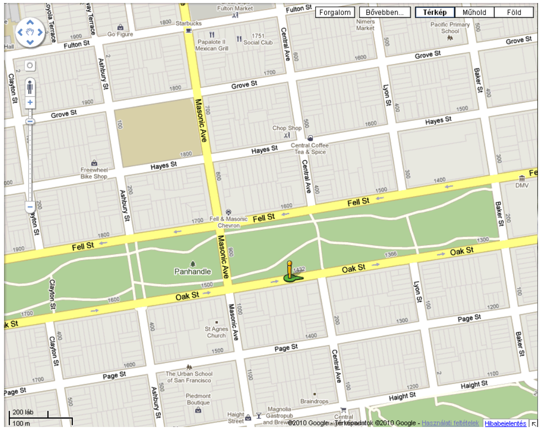
6. APPLICATIONS OF GEOINFORMATION



WebGIS - UM Mapserver

GPS navigation instruments

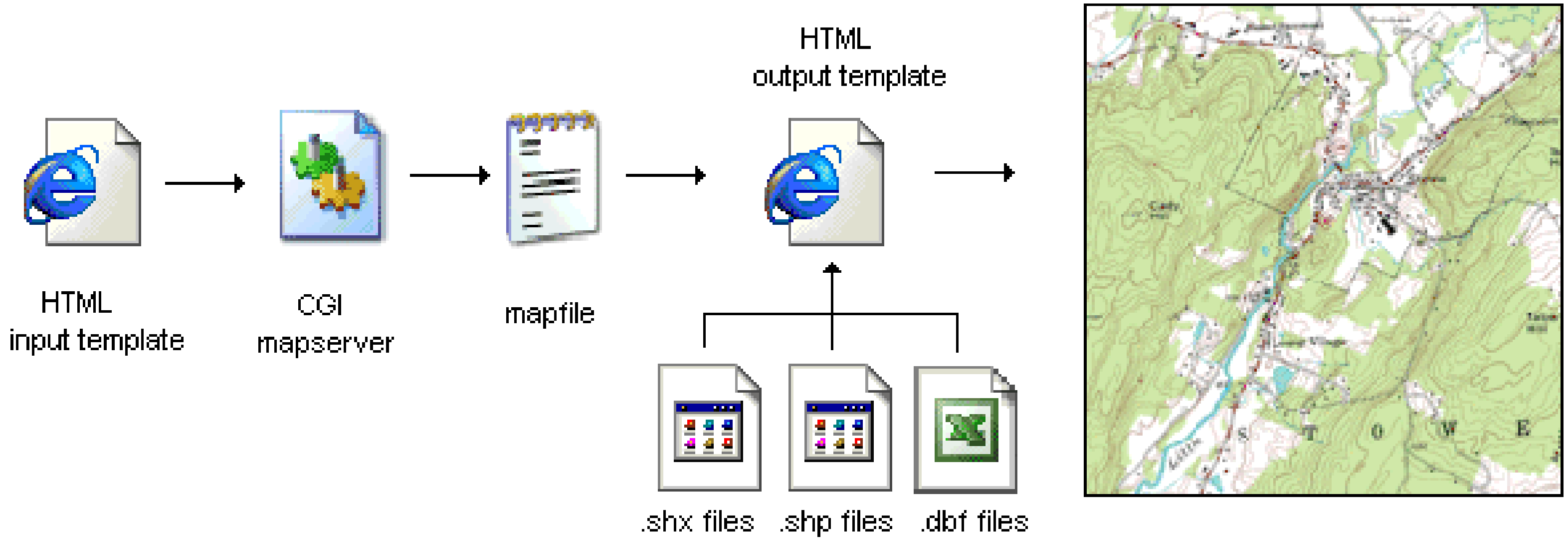
Google Map



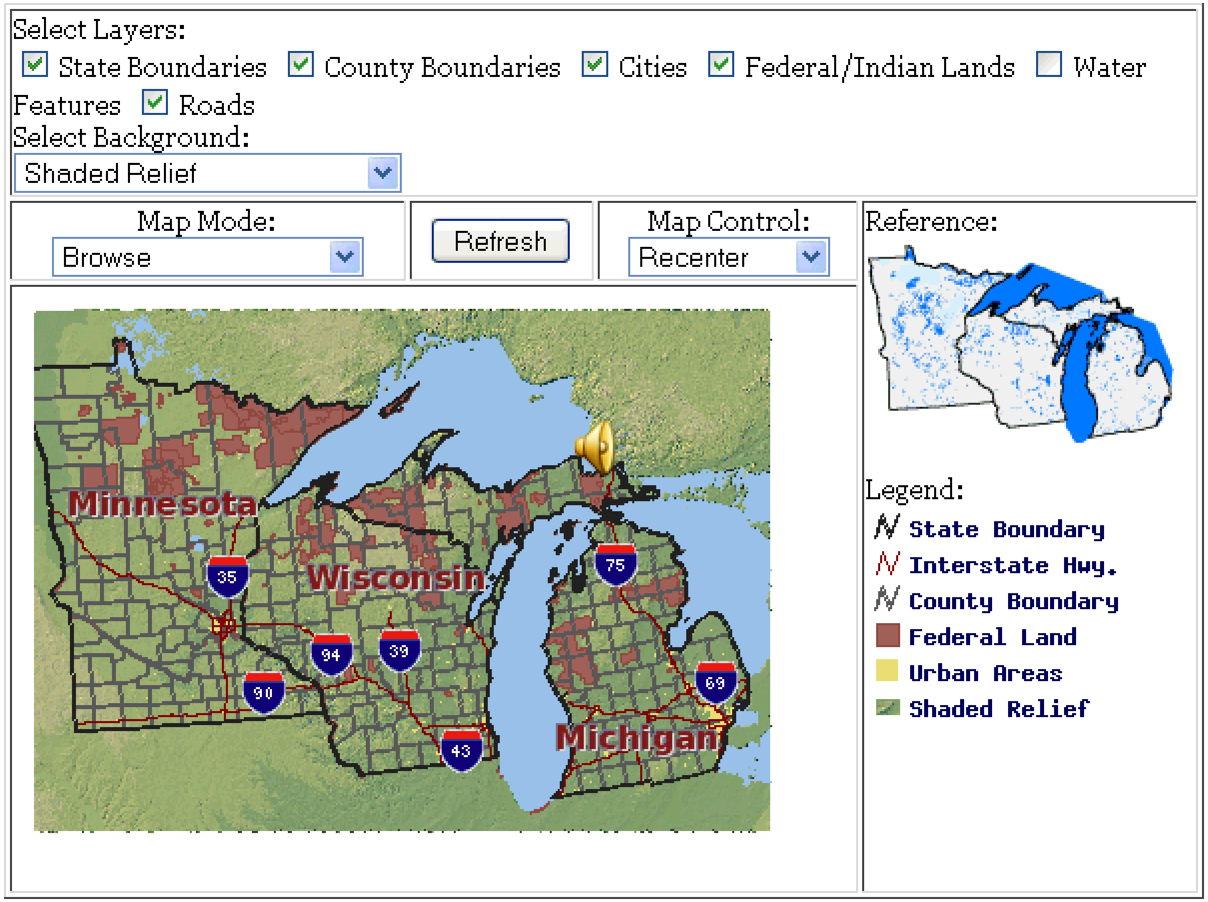
WebGIS - UM Mapserver concept

Client side: web browser

Server side:



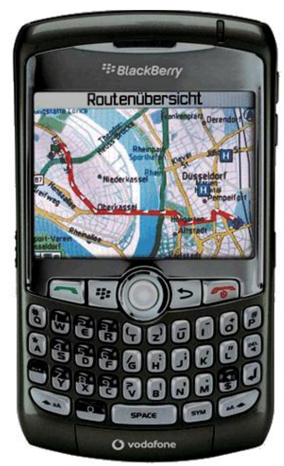
WebGIS - UM Mapserver in operation



Concept of GPS navigation

GPS instrument

PND (Portable Navigatipn Device)
Garmin Nuvi és Motorola MotoNov



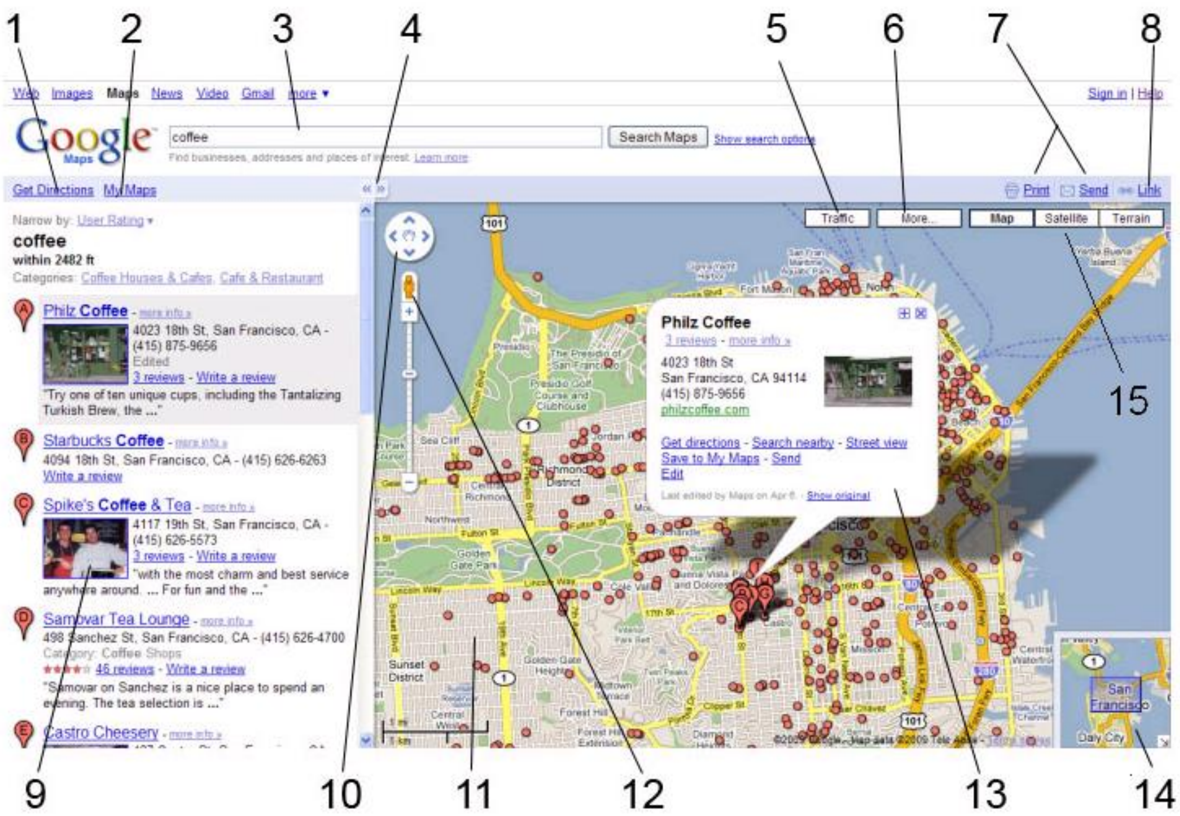
Mobil telefon
GPS navigációval:
iPhone és BlackBerry)

PDA (Personal Digital Assistance):
Hp és ASUS modellek

GPS software iGO

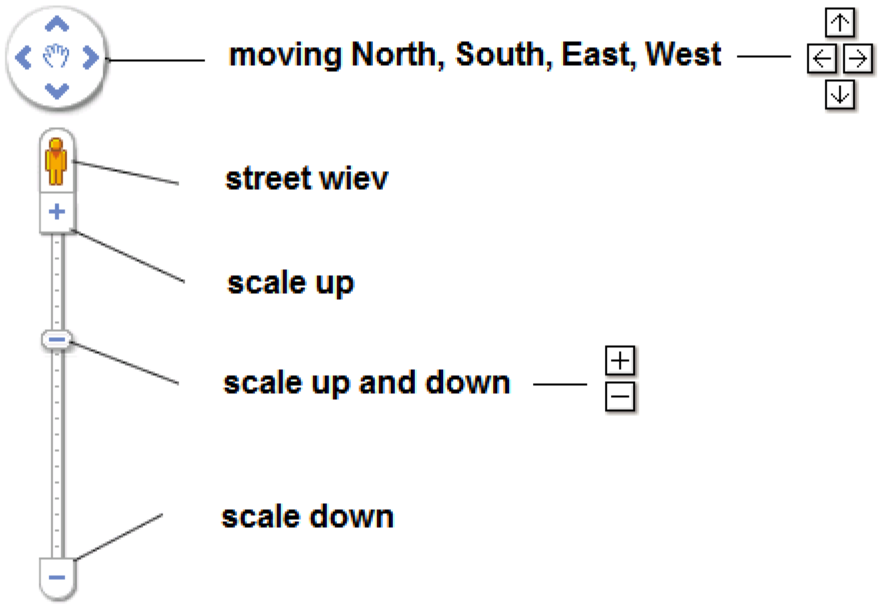
- Siimple setup on PDA or smart phone.
- Full map of Europe and America, displaying 2D and 3D pics.
- Reach POI database (1.8 million points), and input facility for user's POIs.
- Graphical and multilinguistic oral information.
- Simple instrumental operation
- Multi-route planning
- Automatic replanning
- Daily and Night opering mode.
- Displaying GPS coordinates.
- Route storing

Google Map functions



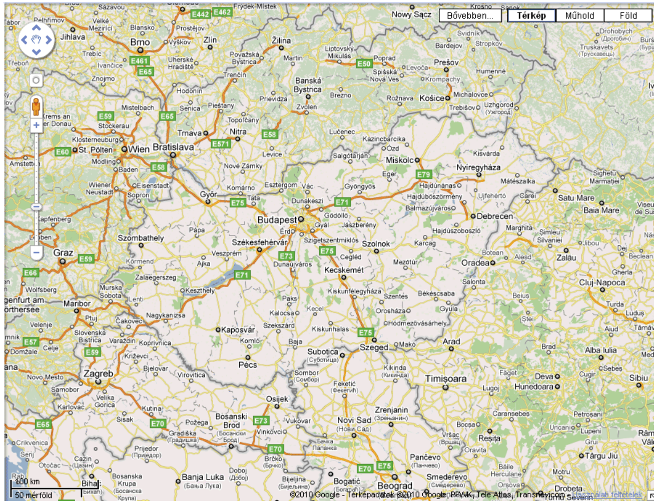
1. Route searching
2. Self-made maps
3. Search
4. Display/Hide
5. Traffick
6. Display/Hidet
7. Print/Send
8. Link
9. Search results
10. Navigation control
11. Map area.
12. Stree wiev
13. Information windov
14. Map
15. Satellite wiev

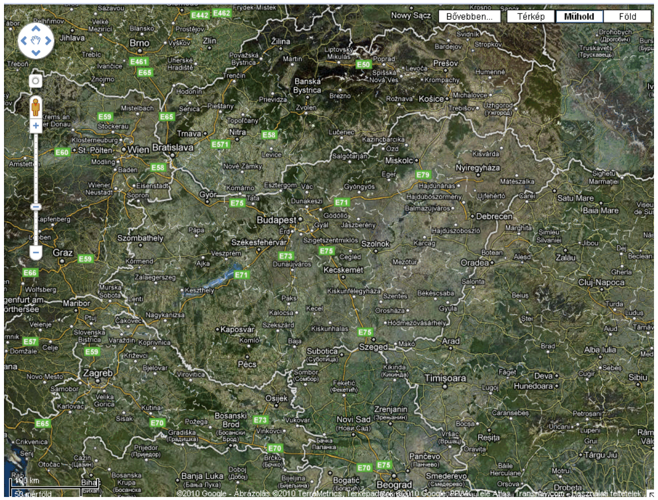
Google Map operations



Google Map wievs

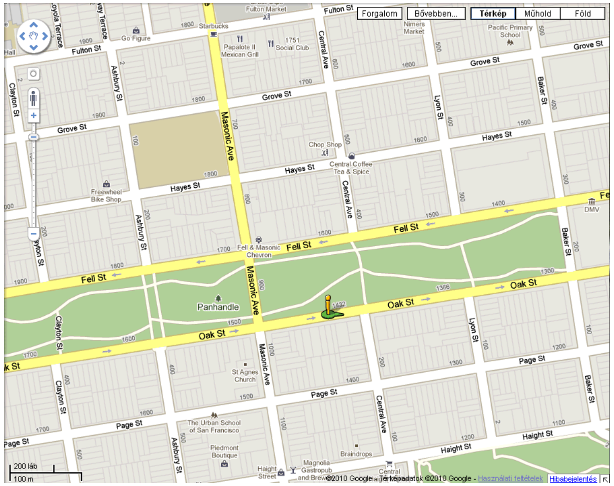
Map

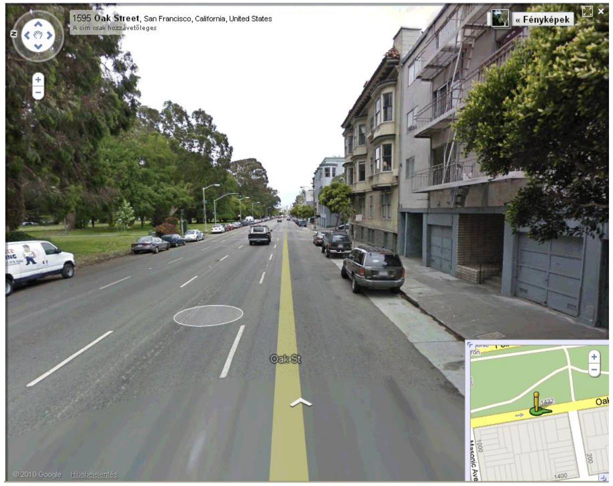




Satellite

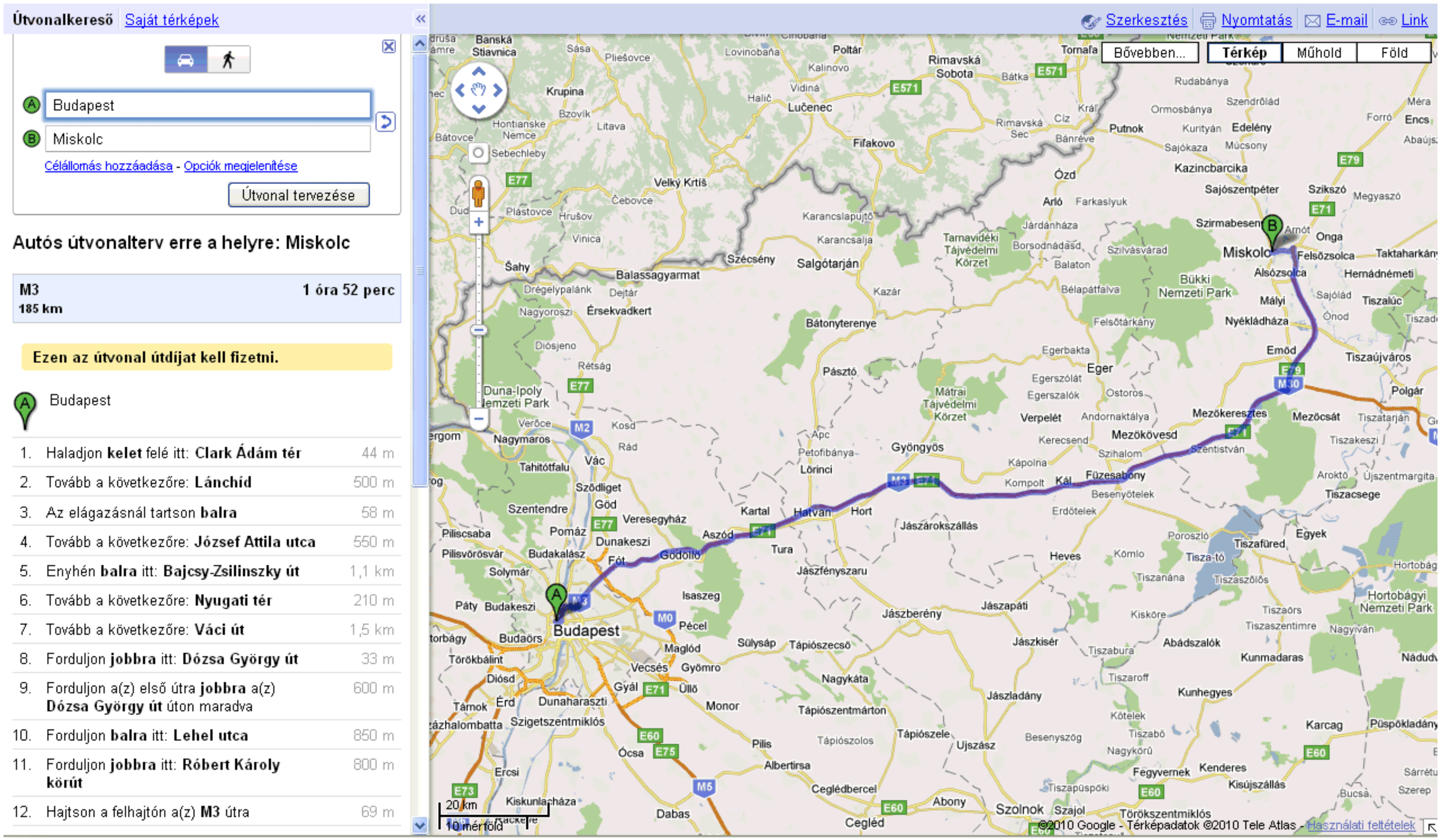
Map



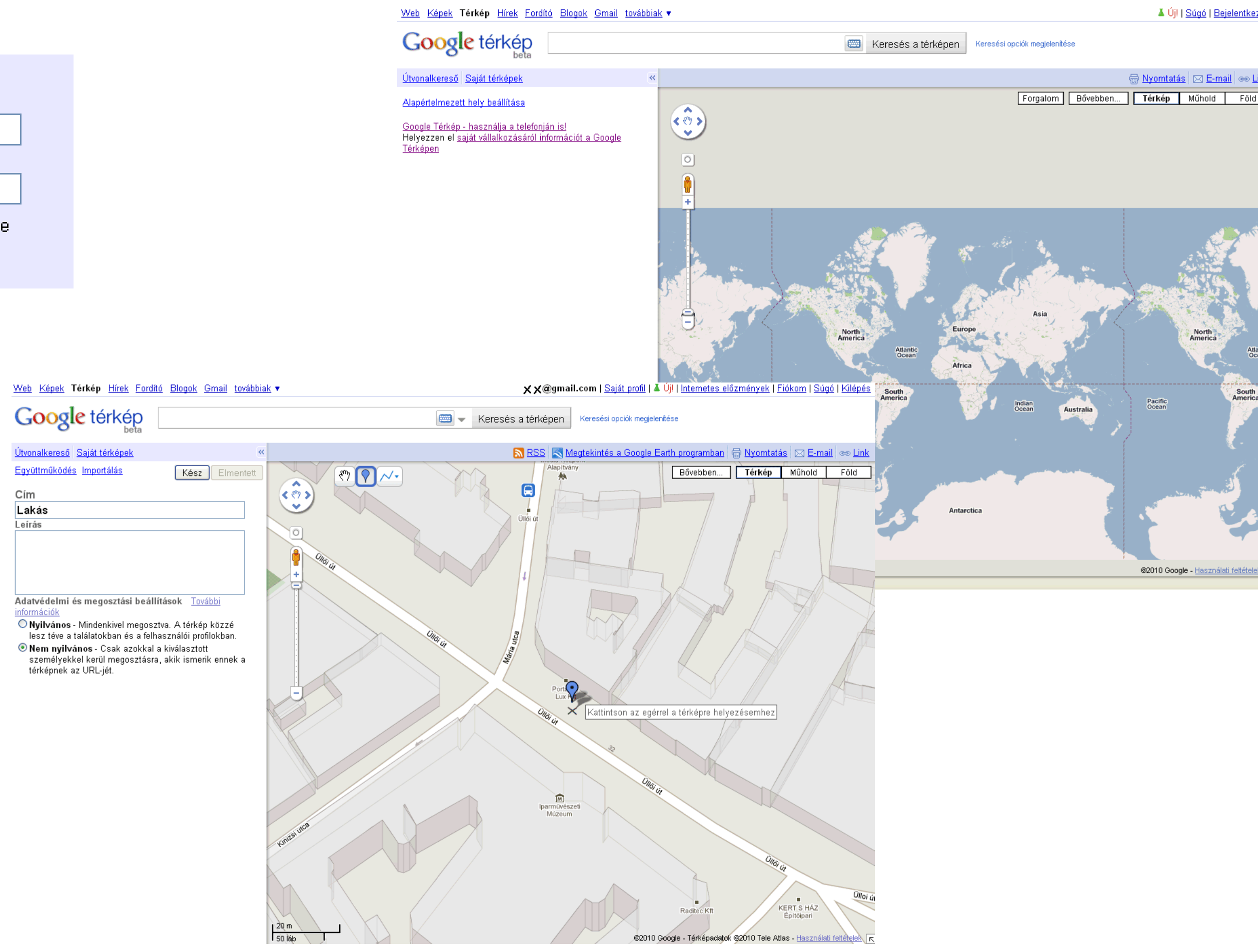


Street

Google Map route planning



Google Map map creation



Point of Interest

Start and End point

Personal POI