

**The 12th Japan-Korea International Symposium on GIS
GIS Day in Kansai 2010, 23rd October, 2010**

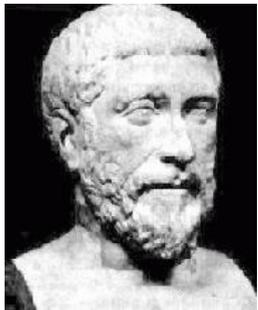
**New Trends of
Geographic Information Systems and
Geographic Information Science
in the World**

**Trends in the Ubiquitous
Spatio-temporal Society and
GIScience&Technology**

Atsuyuki Okabe

When mathematicians say
new theories,
they mean the theories
developed in **20th centuries**
sometimes, including
19th century

BC 5th C



20th C



When geologists say
the **new** period (Cenozoic),
it dates back
65,500,000 years ago!

Precambrian
4500,000,000



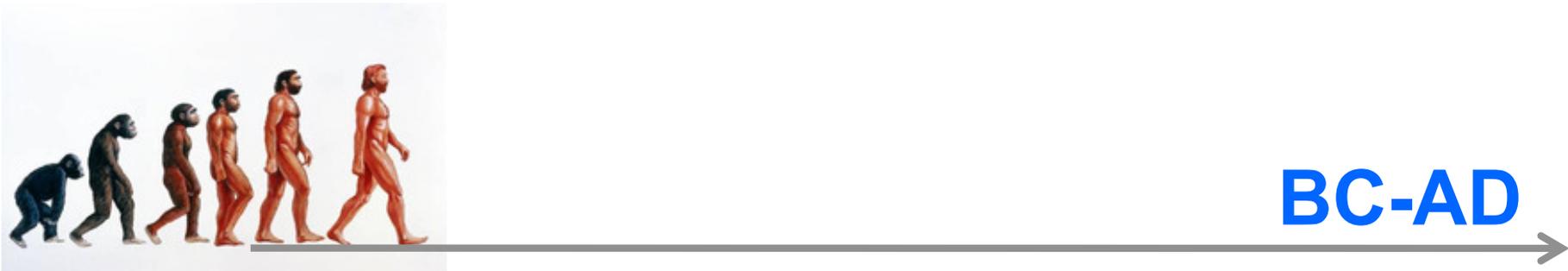
Cenozoic



http://27.media.tumblr.com/tumblr_kur7bdr11s1qzevsbo1_250.jpg

The concept of “new” is relative.

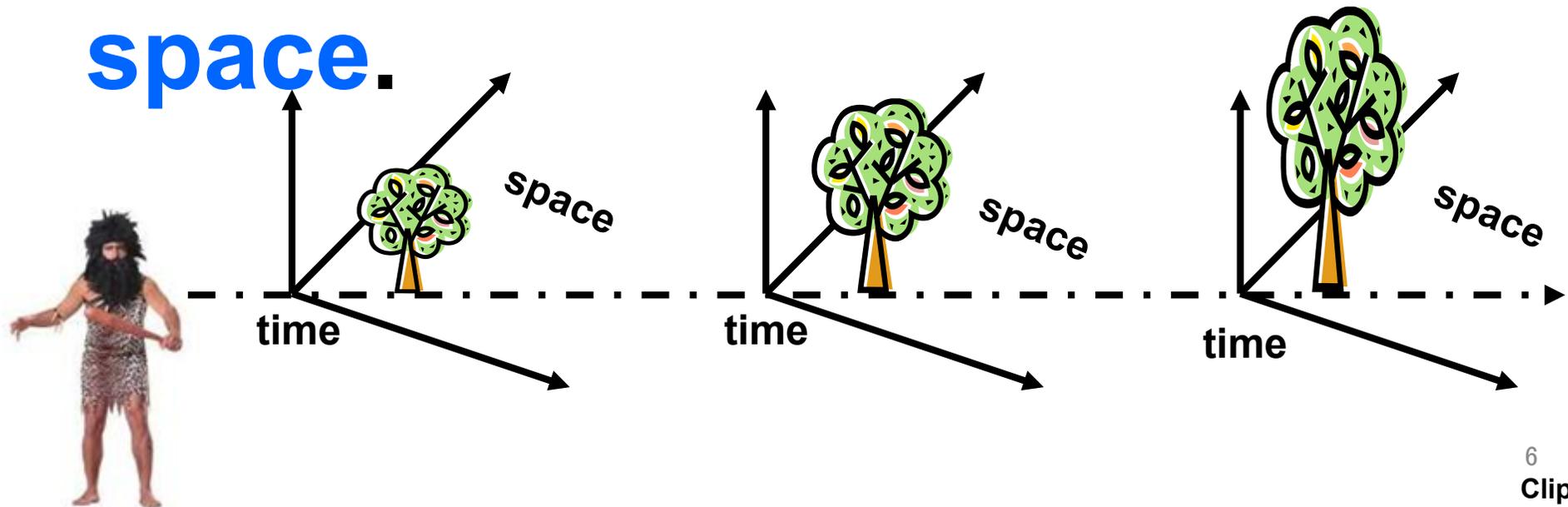
New trends in my talk are
new trends in the time
that humans have existed
in the world.



Contents

- 1 Trends in technologies for utilizing **temporal** information
- 2 Trends in technologies for utilizing **spatial** information
- 3 Two trends in GIS&T toward the **ubiquitous spatio-temporal society**
- 4 A **research challenge** in spatial analysis toward the ubiquitous **spatio-temporal information society**

Since the time that humans have existed in the world, humans have cognized the real world through the dimensions of **time and space.**



Humans gather and record spatio-temporal information comprising **What, What time and Where**, and, and have thus acquired the "**skills in utilizing spatio-temporal information**" by using such information to guide their actions.



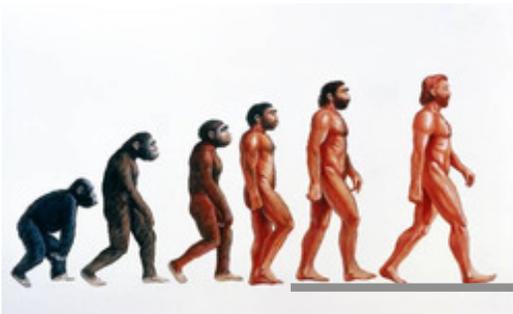


Where to locate
the boar



Clip Art

The humans had been developing the **skills** in utilizing spatio-temporal information over 10,000 years and built up spatio-temporal **technologies**.



**Technologies for utilizing
spatio-temporal
information consists of:**

**Technologies for utilizing
temporal information**

**Technologies for utilizing
spatial information**

1

Trends in technologies for utilizing temporal information

To utilize temporal information

The social reference axis of
time



Techniques to know a
temporal point on the axis

To utilize temporal information

The **social** reference axis of
time



Techniques to know a
temporal point on the axis

Social reference axis of **time**

Naturally, there are temporal elements that are mutually experienced by **everyone in the world since humans have existed.**



Rising and setting of the sun

Four seasons



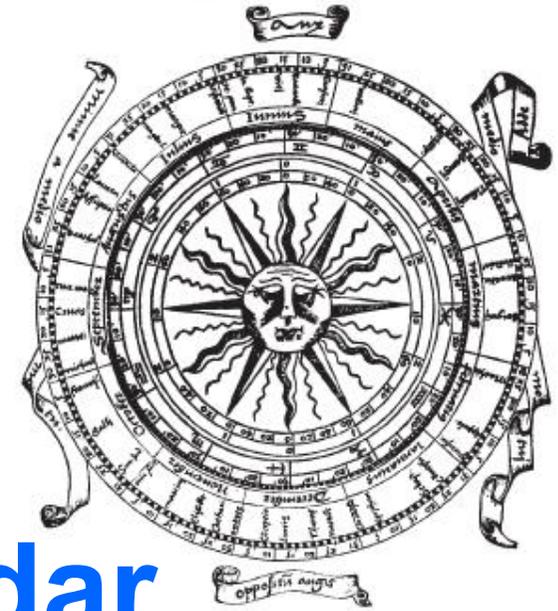
<http://www1.plala.or.jp/chiaki/newpage4.htm>

Social reference axis of **time**

BC45 Julian era

1582 Gregorian Calendar

**common to the entire world,
continuing even to present
day time.**



It is almost a miracle that almost all people in the world share the **same time reference axis!**



Utilizing temporal information

The social reference axis of time



Techniques to know the **temporal point** on the axis

Techniques to know a temporal point

BC2000 **solar** clock

BC1500 **water** clock

BC700 **sand** clock

BC700 **candle** clock



<http://en.wikipedia.org/wiki/File:Sundial-from-Marcianopolis.jpg>

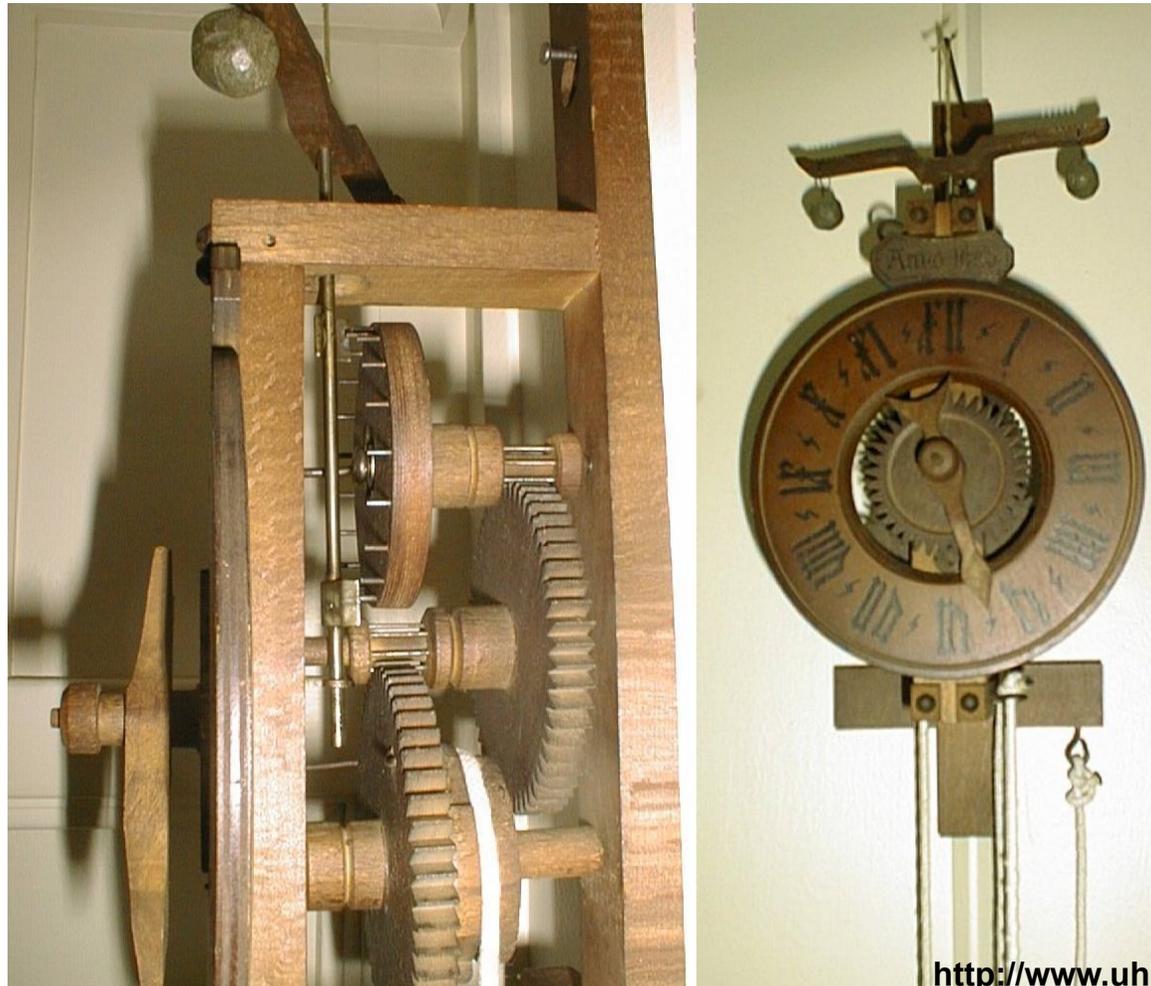
http://en.wikipedia.org/wiki/File:AGMA_Clepsydre.jpg

http://en.wikipedia.org/wiki/File:Wooden_hourglass_3.jpg

<http://en.wikipedia.org/wiki/File:Kerzenuhr.jpg>

Techniques to know a temporal point

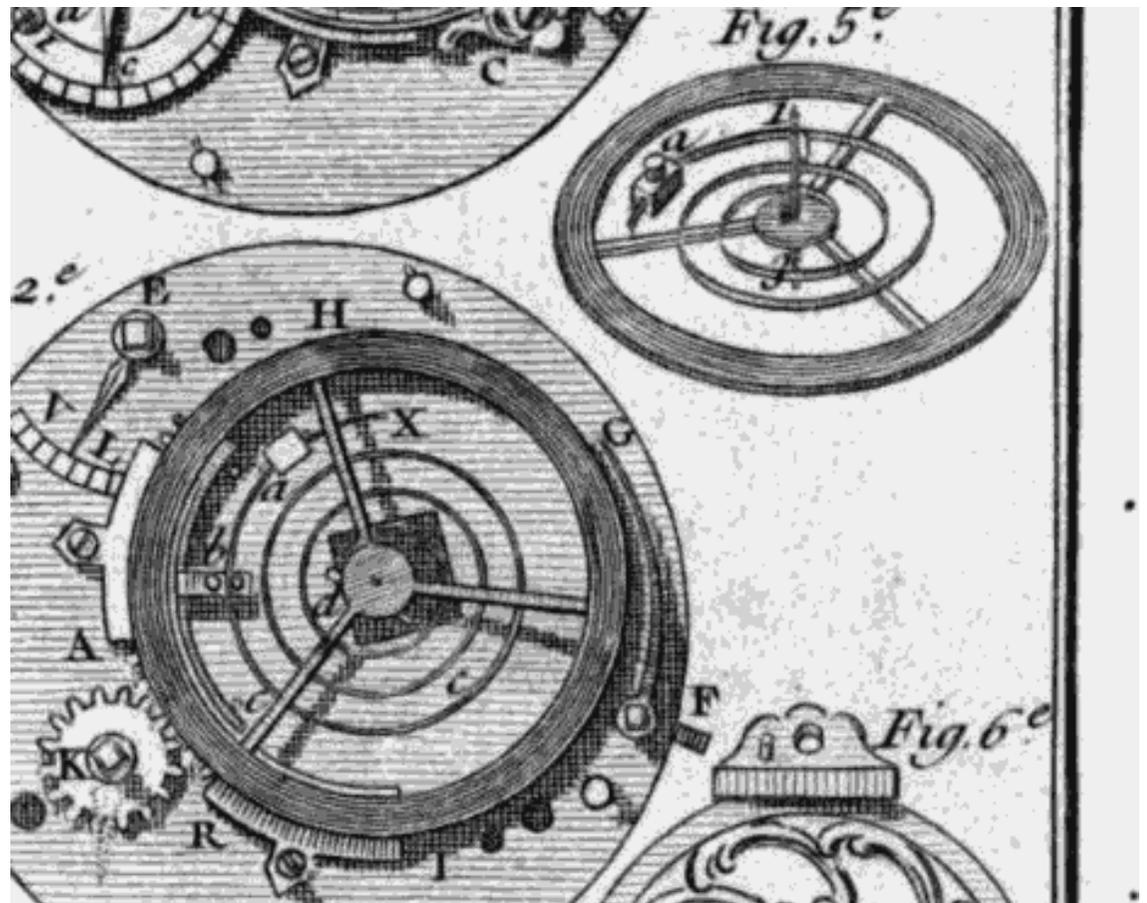
13th **mechanical** clock



Groundbreaking technology

17thC

invention of
the **balance
spring**
spring



Dawn of a new era of **mobile** time technology

pocket watches



However,
this did not spread amongst
the general public until the
first half of the 20th century

It took more than 200 years!

1923

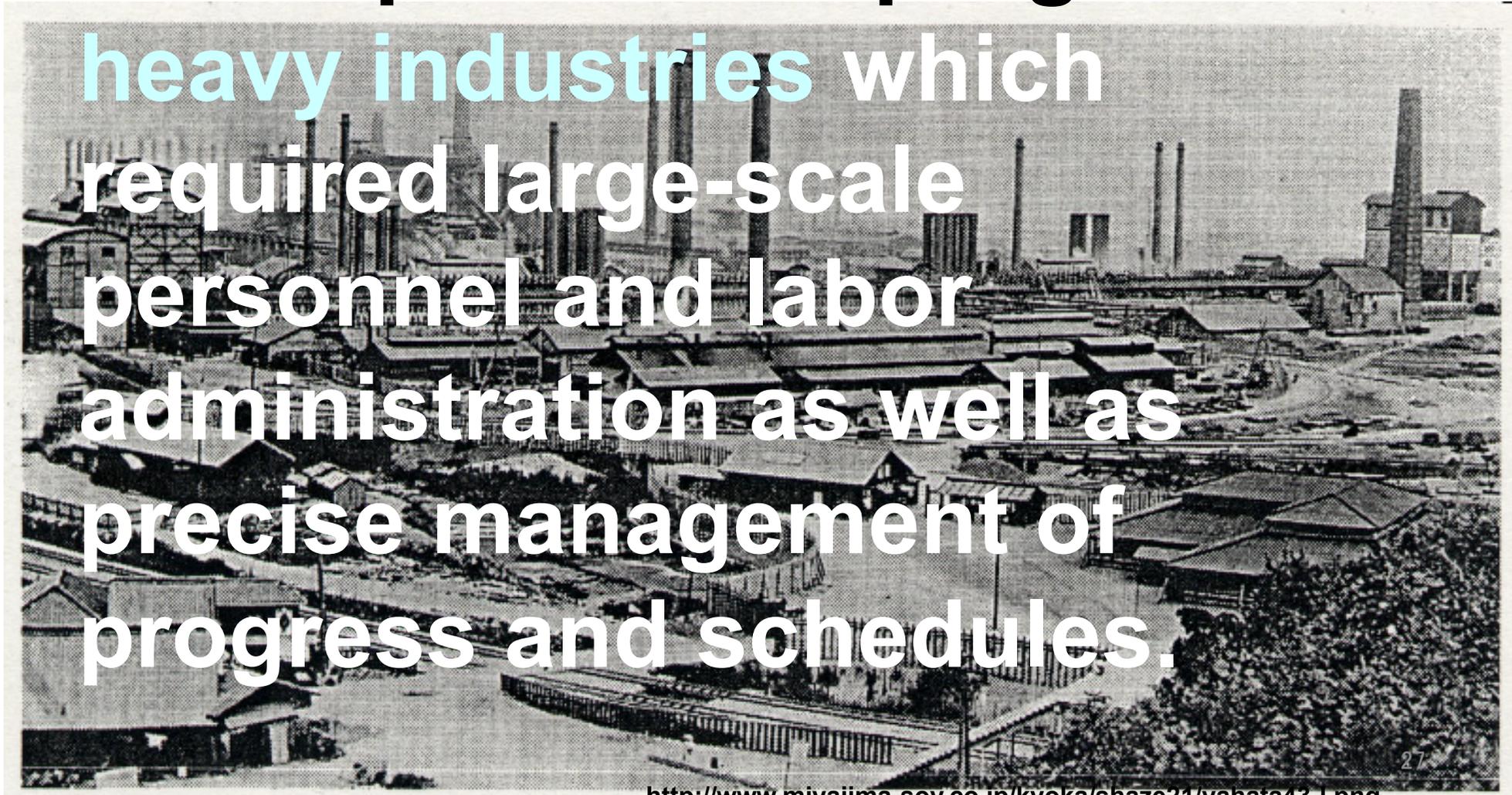


A large majority of people had come to own wrist-watches, thus facilitating the emergence of the **technology of ubiquitous temporal information**

..... that supported the social infrastructure for people to easily know time whenever and wherever they wanted. This facilitated the efficient utilization of time, and was thus

.... instrumental in the rapid development and progress of

heavy industries which required large-scale personnel and labor administration as well as precise management of progress and schedules.



Ubiquitous temporal information **revolution**

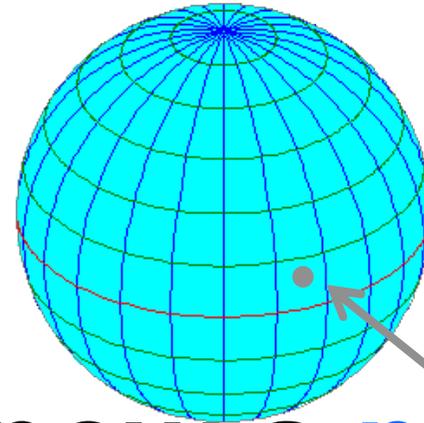
The ubiquitous temporal
information technology had
established the **ubiquitous
temporal information society**
in the 20th century.

2

Trends in technologies for utilizing **spatial** information

To utilize spatial information

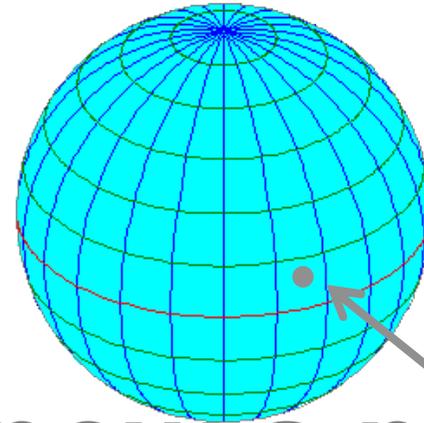
The social reference axis of
space



Techniques to know a **point**
on the spatial reference

To utilize spatial information

The social reference axis of
space



Techniques to know a point
on the spatial reference

Social reference axis of space

Unfortunately, commonly experienced elements such as the rising and setting of the sun and the changing of the four seasons was undiscoverable.

Hipparchus

126BC

**latitude and
longitude**



However, in our current 21st century era, instead of utilizing the geographic coordinates of latitude/longitude **in their day to day lives,**

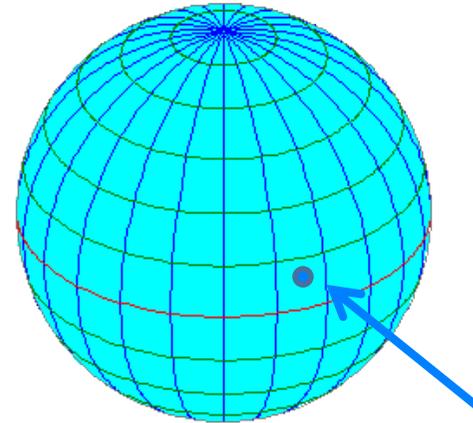
...., people make more use of the **wide variety** of other elements such as address, post codes and telephone numbers.



As yet, we do **NOT have any socio-spatial reference axis that **all people of the world can commonly and easily use in their daily lives.****

To utilize temporal information

The social reference axis of
space



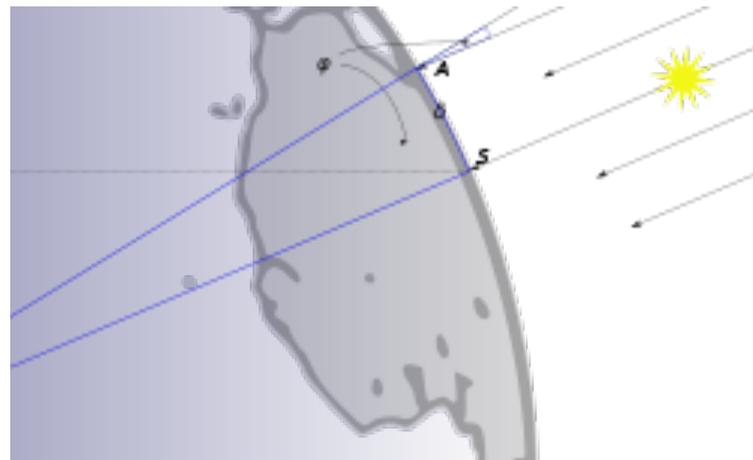
Techniques to know a point
on the spatial reference axis

Techniques to know a location

The methods for knowing **latitude** and **longitude** were developed separately.

Techniques to know latitude

Eratosthenes 276-195BC



Techniques to know latitude

1200AD Quadrant



<http://www.aip.org/history/cosmology/tools/images-tools/quadrant52002m.jpg>

1731 Octant



1759 Sextant



<http://img.villagephotos.com/p/2004-7/767317/TROUGHTONSIDVW001.JPG>

<http://www.antiquesextant.com/images/sext8sm1.jpg>

Techniques to know longitude

NO techniques
over many centuries!

Many merchant ships were stranded and washed ashore causing the loss of a vast amount of wealth.



Reward

In 1714

the **British parliament** announced a reward to anyone who would discover techniques for precisely measuring longitude.

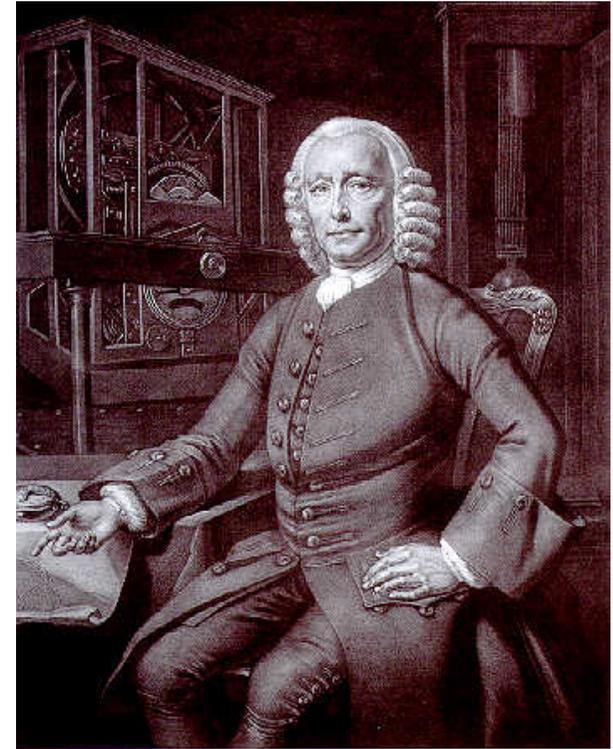
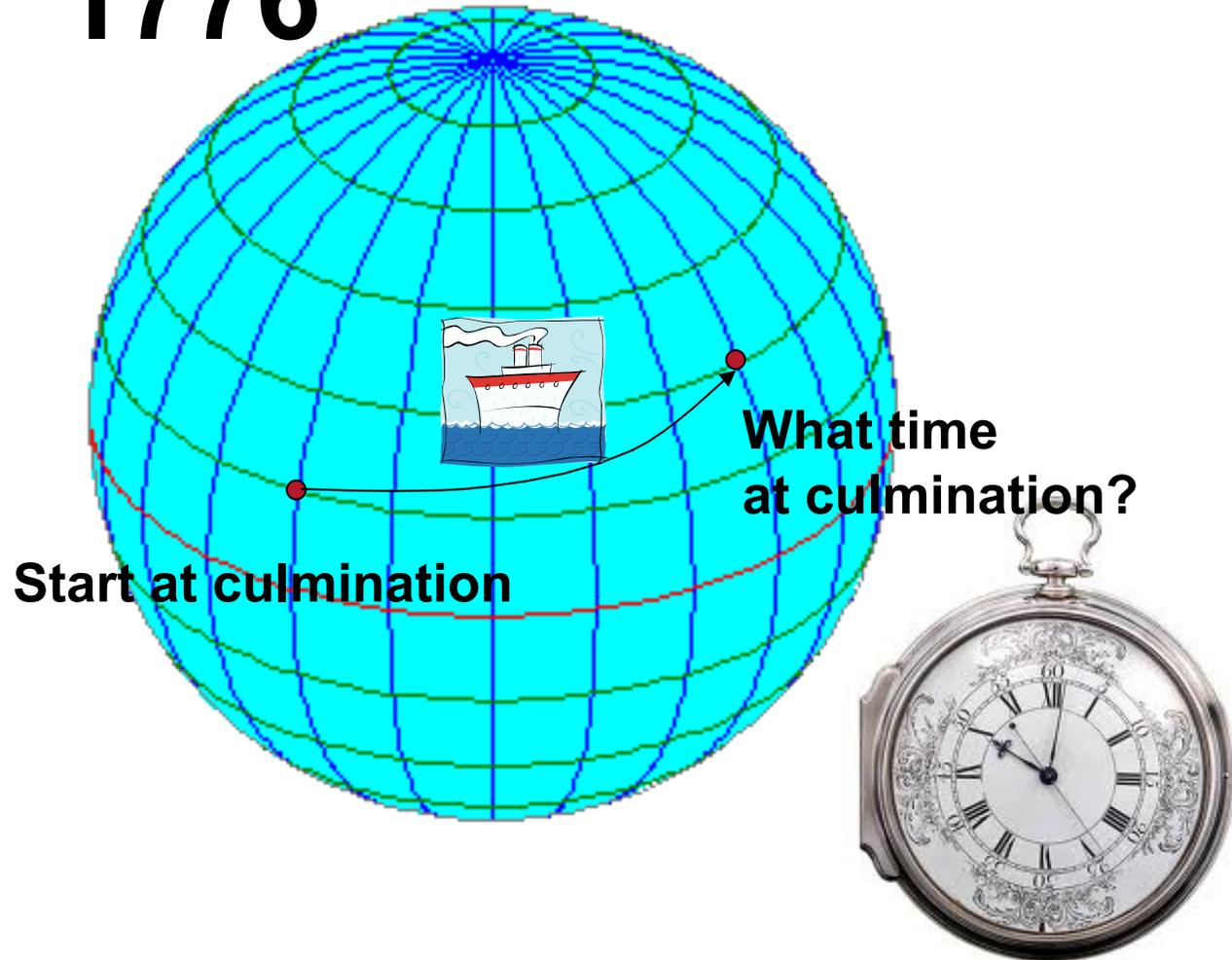
How much the reward?



**The reward was
so large that it could possibly
be equivalent to **king's
ransom.****

John Harrison

1776

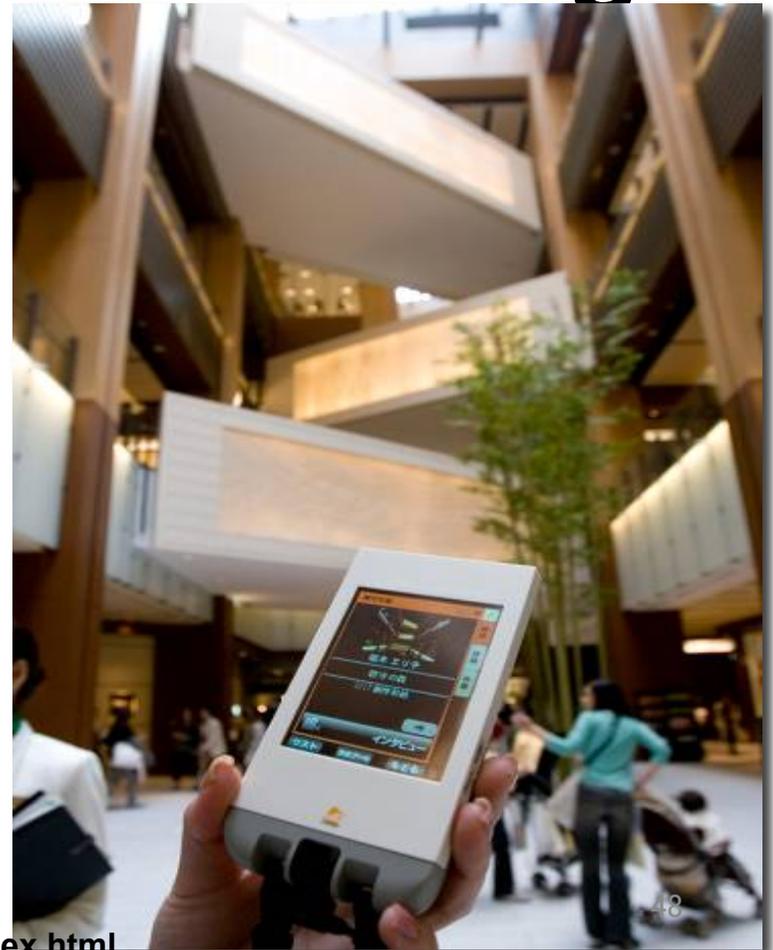


Now, GPS

In **1996**,

general public use of the **GPS**
was established and it
became easily possible to
determine latitude and
longitude.

However, the technology for determining **indoor locations** is still in the process of being developed, and



...., the smooth **coordination of indoor and outdoor location points** is still only in its research phase.



The current reality therefore is that we have **NOT yet established the technology which would enable us to determine spatial **points with ease whenever and wherever we want.****

**We had established the
ubiquitous temporal
information society
in the 20th century,
but we have NOT yet
established the
ubiquitous spatial
information society.**

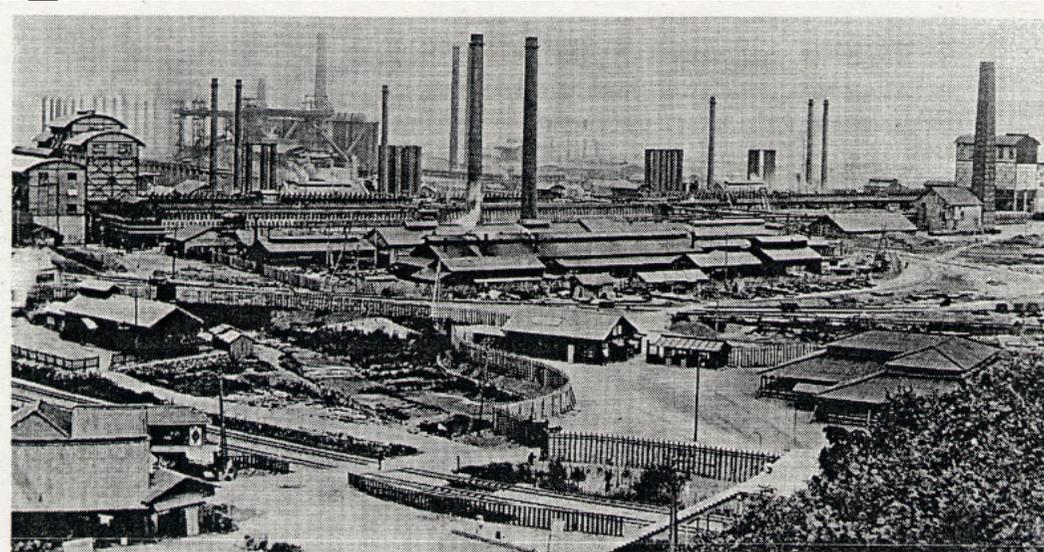
Hopes

This is not something to be disappointed about; rather, it is time to have **hopes for the future.**



Recall

Technologies for ubiquitous **temporal information brought a revolutionary change in society in the 20th century.**

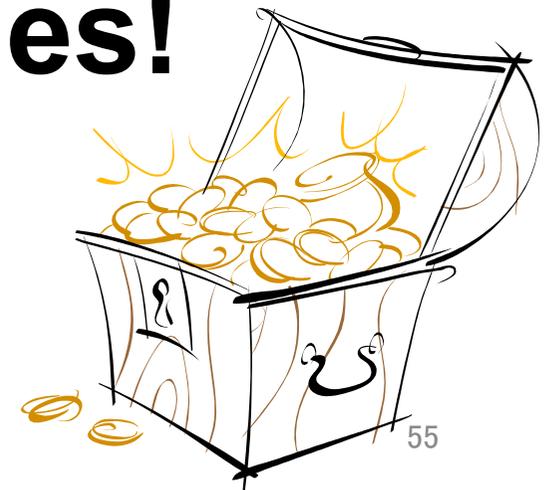


Ubiquitous spatial information revolution

**One can expect that similarly
ubiquitous spatial information
will facilitate a large social
development in the future.**

Great reward

Hopefully, Parliaments in the world announce a great reward to anyone who would discover ubiquitous spatial information technologies!



3

**Two trends in GIS&T
toward the ubiquitous
spatio-temporal
society**

GIScience & Technology

The science and technology that **supports a "ubiquitous spatio-temporal society"** can be considered as none other than GIScience & Technology

An aerial photograph of a large, snow-covered mountain range. The central focus is a prominent, jagged peak with a wide, snow-filled valley at its base. The surrounding terrain is also covered in snow, with various ridges and valleys visible. The sky is a clear, pale blue. The overall scene conveys a sense of vastness and scale.

Trends of its expansion

Two-hold:

**just as a tall mountain has a
broad base;**

**a mountain cannot be tall
unless it has a broad base.**

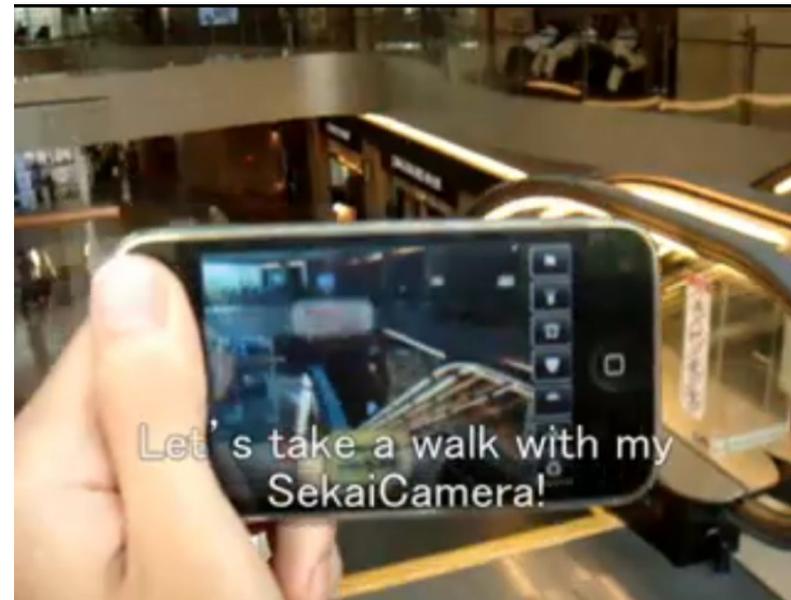
Photo:K.Yamada

One trend

focuses on how broad the mountain base is, i.e.

**it promotes GIS&T that
average people can make use
of with ease.**

It has become possible for people to **enjoy** spatio-temporal information with much ease using instruments such as the iPhone and GoogleMap.



The other trend

focuses on the height of the mountain, i.e.,

it is the cutting edge

GIScience&Technology

promoted by **experts** in the field.

Clip Art



GIScience & Technology

Acquisition

Management

Analysis

Synthesis and

Communication

of spatio-temporal information.

**Almost a daily
advancement in**

Acquisition

Management

Analysis

Synthesis and

Communication

by Information technologies

Much delayed in

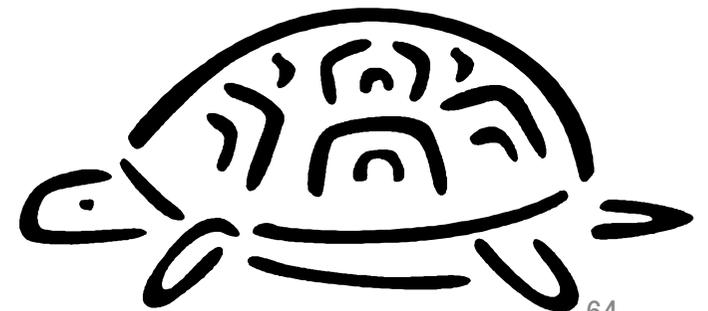
Acquisition

Management

Analysis

Synthesis and

Communication



Unless the progress in this area deepens further, there can virtually be **no possibility** of utilizing advanced spatio-temporal information.



One of the research themes in this area is that of **real-time spatio-temporal analysis and synthesis**



Real-time spatio-temporal analysis and synthesis

immediate and on the spot
analysis & synthesis of
information as it occurs at
any given time and place, and
setting guidelines for actions
through this process.



The successful realization of a ubiquitous spatio-temporal society is highly dependent on such science and technology.



Real-time spatio-temporal analysis and synthesis

4

**A research challenge in
spatial analysis
toward the ubiquitous
spatio-temporal
information society**

Experiments toward the ubiquitous spatio-temporal society

Ubiquitous art tour in Mid Town

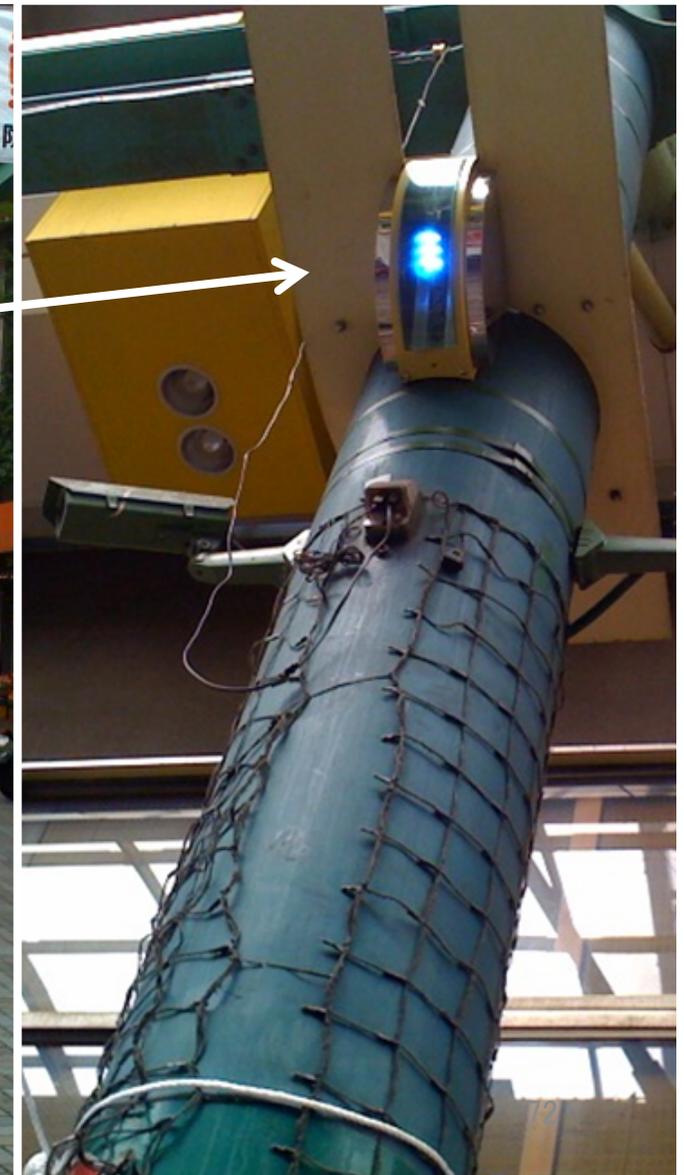


Experiments toward the ubiquitous spatio-temporal society

Tokyo ubiquitous plan
GINZA



Experiments toward the ubiquitous spatio-temporal society



The systems have not yet provided comfortable ubiquitous spatio-temporal information.

A reason for it is: the systems are designed assuming the physical (Euclidean) space.

People behave in the subjective space by conceptualizing the physical space in their mind. Users feel the gaps between the physical space and their conceptualized space.



A research challenge

**How to model subjective,
abstract, and conceptualized
spaces mathematically?**



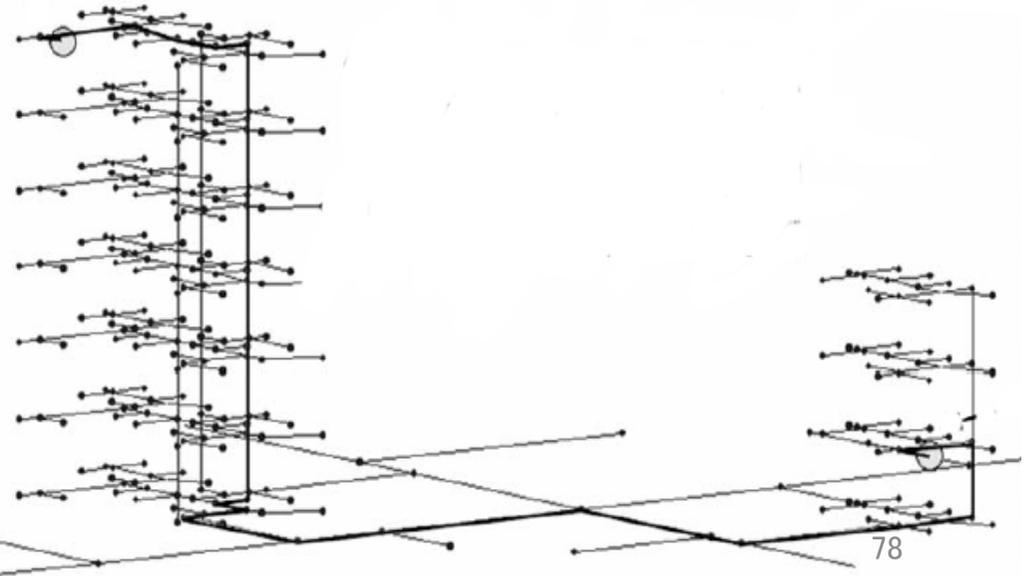
Real space



Geometrical objects in the Euclidean space

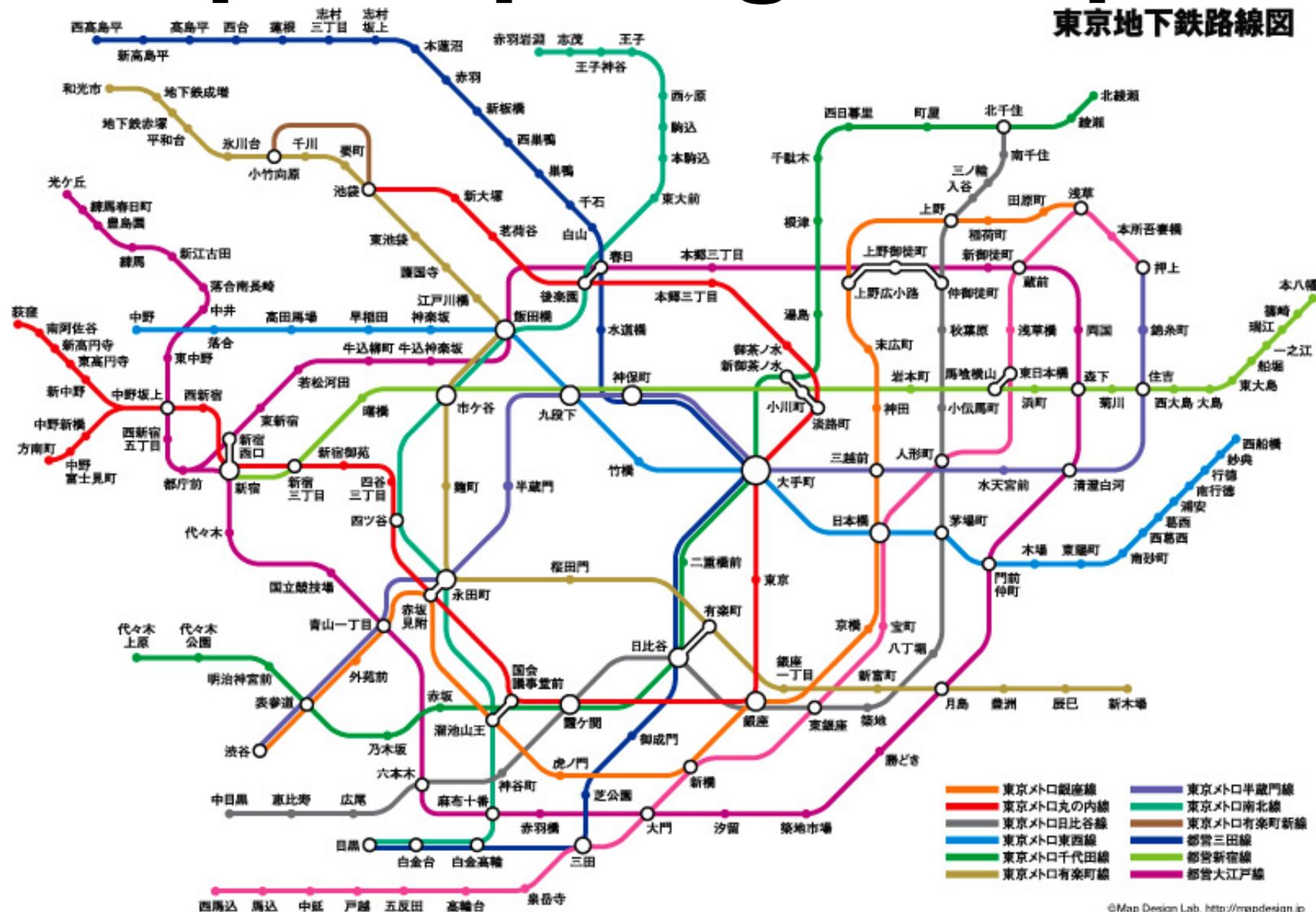


Network-topological space



Source: Kwan, M-P. and Lee, J. (2005)

Graph-topological space



Abstractions of space

Euclidean space

Non-Euclidean space

Network-topological space

Graph-topological space

Researches  at here!

Lower 'stream of space'



Upper stream or 'origin' of space?



Euclidean

Non-Euclidean

Network Topology

Graph Topology

**What are the minimum
axioms of space?**

The 'origin' of space

A topological space (X, F) is a set X of points and a family F of subsets of X which satisfies the following axioms:

A1: The union of any number of members of F is a member of F .

A2: The intersection of any finite number of F is a member of F .

The simplest topological space

Indiscrete space

$$F = \{\emptyset, X\}$$

Chaotic space

Spaces represented by general topology

Indiscrete space,

$T_0, T_1, T_2, T_3 \dots \dots \dots$

**graph, network, non-Euclidean
and Euclidean spaces**

Upper stream of space



Application of general topology to the conceptualization of subjective spaces

An initial attempt
by Ai Maeda

1931-1987



<http://d.hatena.ne.jp/images/keyword/9973.jpg>



An example of indiscrete space





The opposite space

六道の辻、西福寺のお堂の横に飾られた地獄図

http://blog.so-net.ne.jp/_images/blog/_41d/staff_for_one/8818930.jpg

**Many attractive
research challenges to
realize the ubiquitous
spatio-temporal
society!**



**Thank you for your
kind attention**