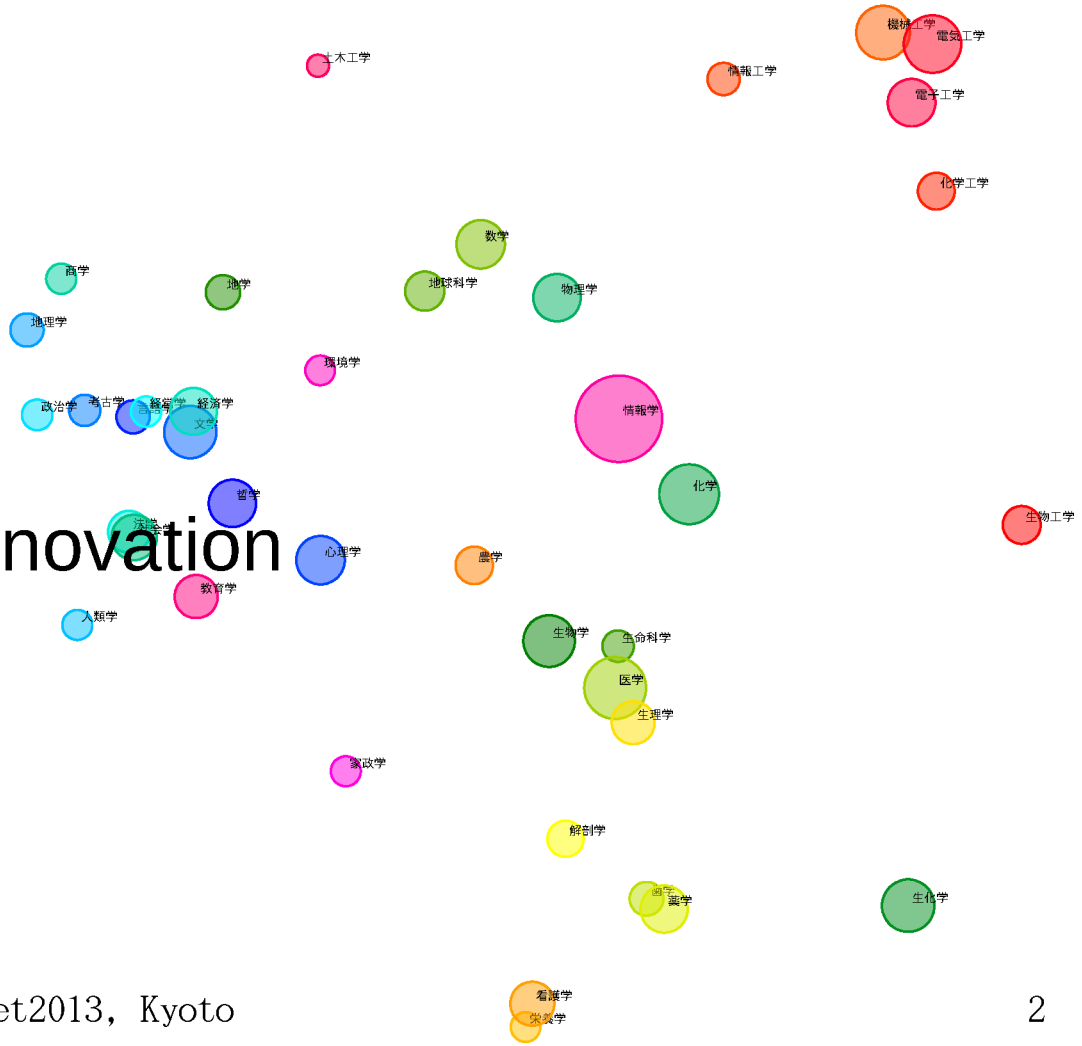
Academic Landscape Timelapse



Yuji FUJITA,
Nihon University
Mari JIBU
OECD, JST

What is it?

- Visual representation of the whole academic knowledge domain
- To help
  - Conceive
  - Decide policy
  - Pickup/encourage innovation



Innovation = hybrid of known

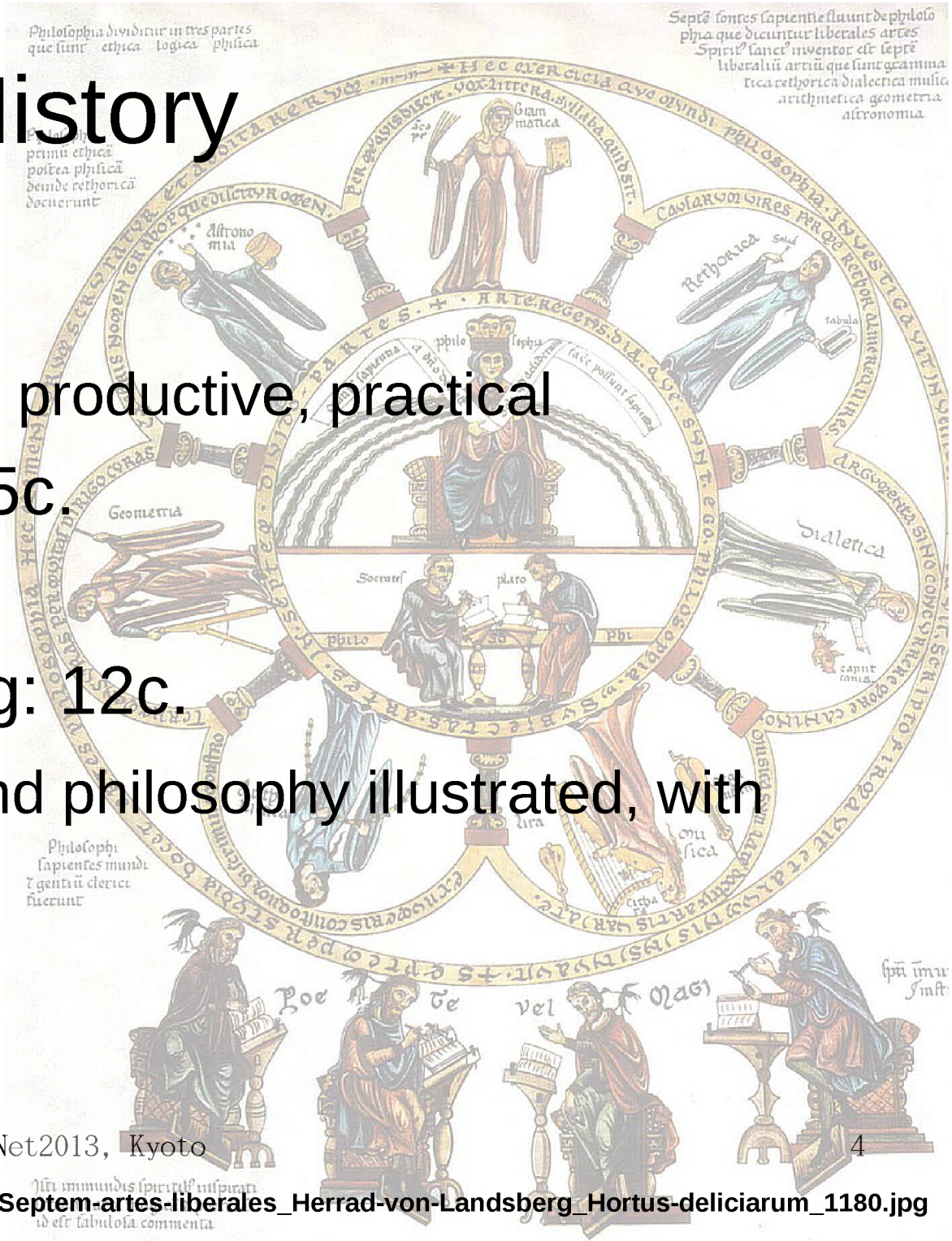






History

- Aristotle: -4c.
  - 2 layers, theoretical, productive, practical
- Martianus Capella: 5c.
  - Seven liberal arts
- Herrad of Landsberg: 12c.
  - Seven liberal arts and philosophy illustrated, with structure
- Renaissance: 16c.



http://commons.wikimedia.org/wiki/File:Septem-artes-liberales_Herrad-von-Landsberg_Hortus-deliciarum_1180.jpg

Raphael



http://en.wikipedia.org/wiki/File:Sanzio_01.jpg

Art to science

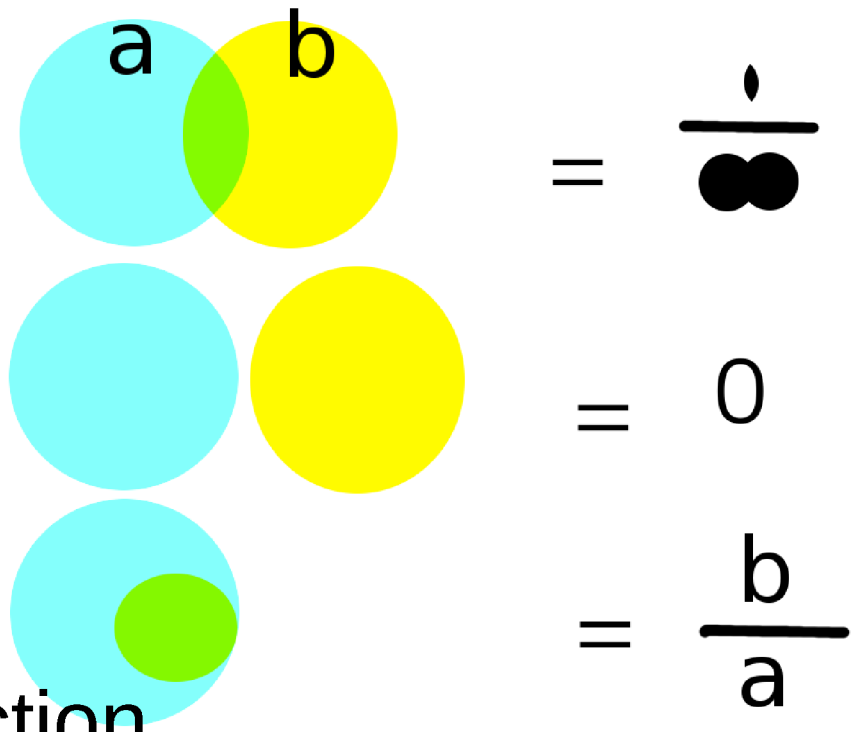
- Experience, experiment and reasoning
  - Based on data
  - Well defined method written in numbers and formulas

Drawing for our project

- project of science for science policy
- need of comprehensive and scientific understanding of the whole knowledge domain
- Mutual distance of subjects: Jaccard index
  - Subject size = Google scholar hit size
- MultiDimensional Scaling (MDS) will give the plot of subjects

Jaccard index

- Proximity of two classes



$= \frac{\cdot}{\bullet\bullet}$

$= 0$

$= \frac{b}{a}$

- Metric function
- Easy to implement/compute

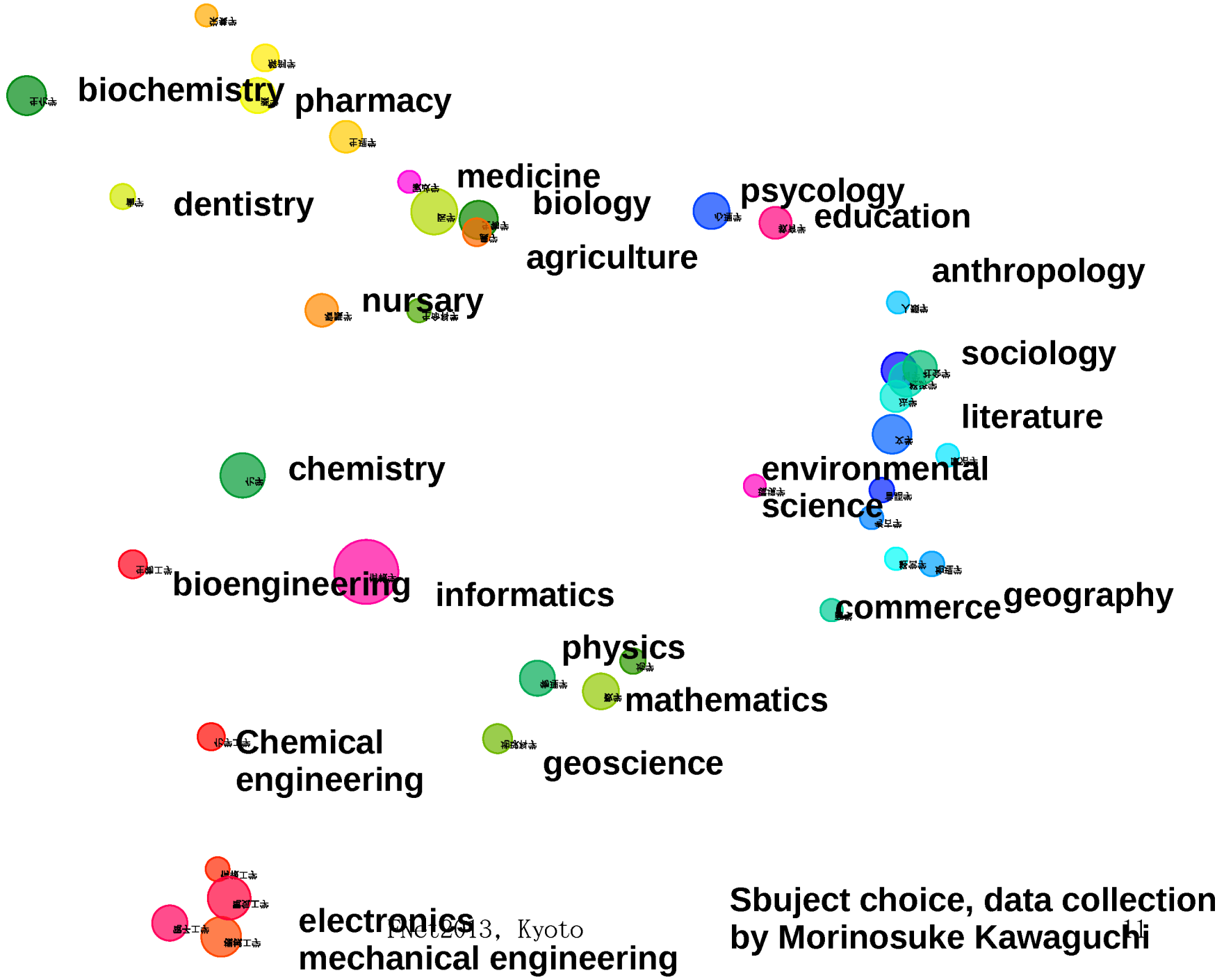
MDS

- Classical MultiDimensional Scaling
- Mutual distance table → geometric arrangement
- Coordinates = eigendecomposition of matrix

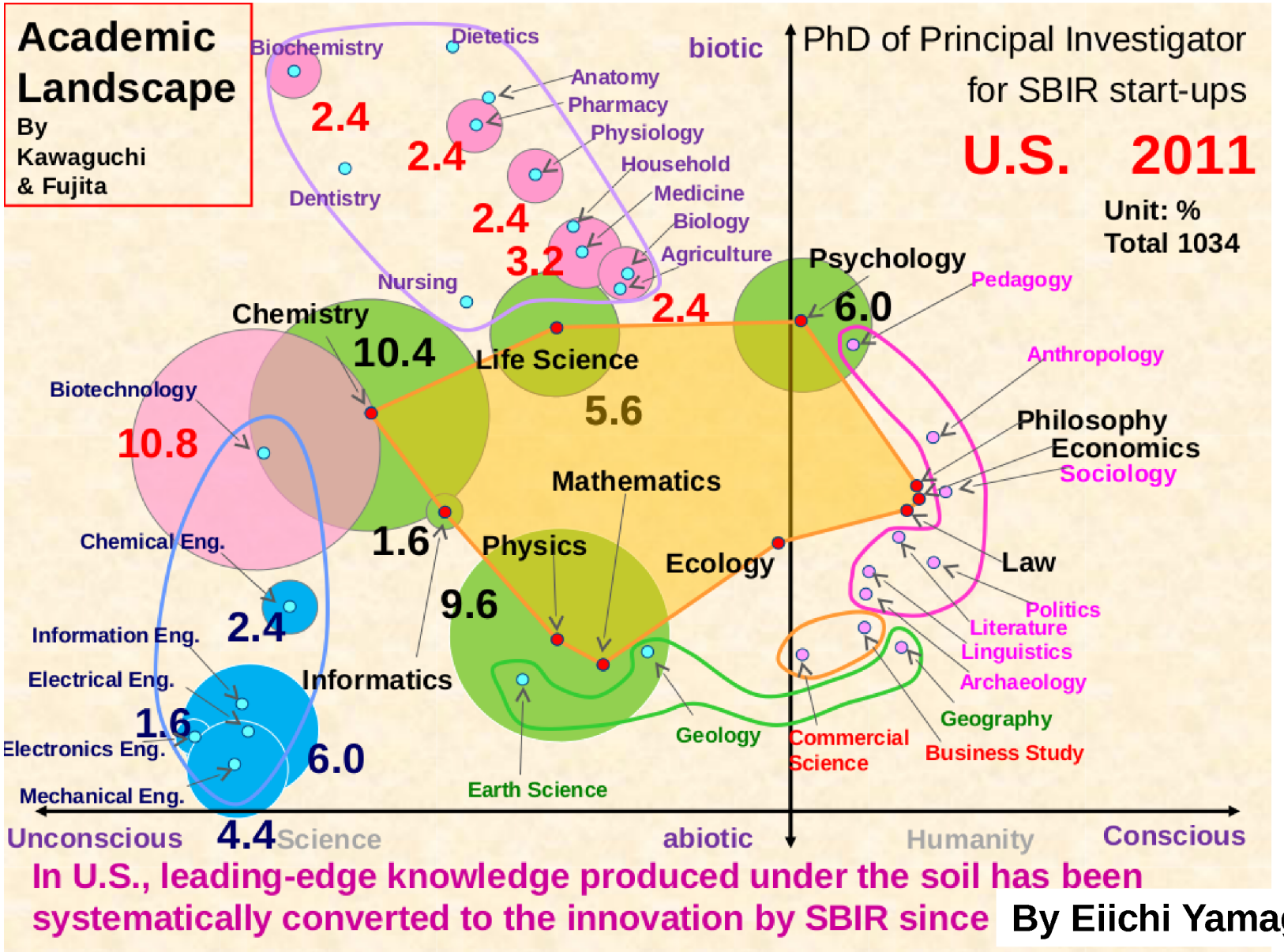
$$\mathbf{C} = \sum_{i=1}^{N} \lambda_i \boldsymbol{v}_i^{\mathrm{T}} \boldsymbol{v}_i \approx \lambda_1 \boldsymbol{v}_1^{\mathrm{T}} \boldsymbol{v}_1 + \lambda_2 \boldsymbol{v}_2^{\mathrm{T}} \boldsymbol{v}_2$$

MDS advantage

- Consistent
  - Identical data always gives identical coordinates
- Continuous
  - Small change in data source makes small change in the drawing
- Dimensionality reduction
  - Quantitative estimation of lost information


biochemistry
pharmacy
medicine
dentistry
biology
psycology
education
agriculture
anthropology
nursary
sociology
literature
chemistry
environmental
science
bioengineering
informatics
commerce
geography
physics
mathematics
Chemical
engineering
geoscience
electronics
mechanical engineering
Sbuject choice, data collection
by Morinosuke Kawaguchi

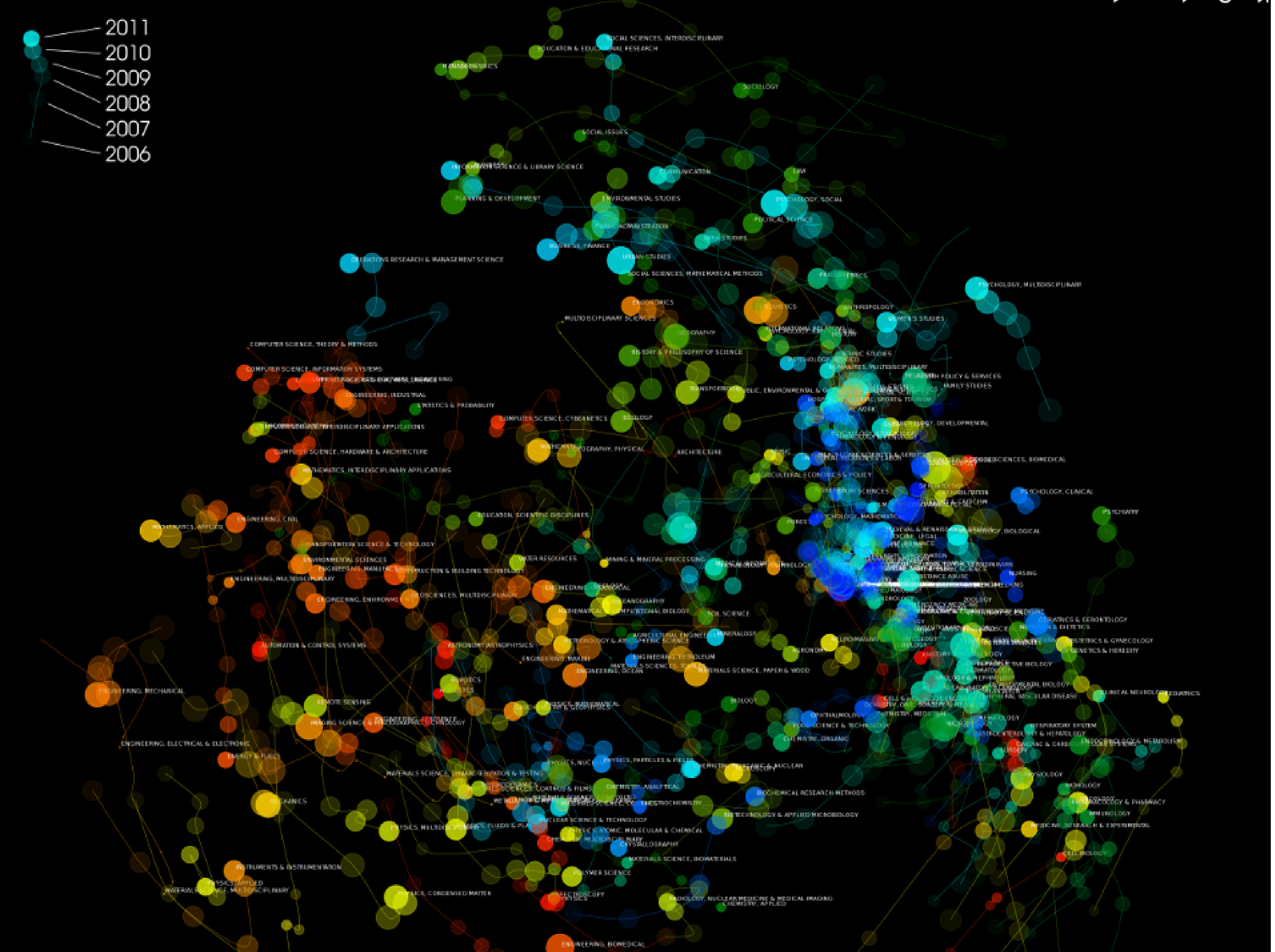
The chart and application



By Eiichi Yamaguchi

Apply to time series data

- Web of Science by Thomson Reuters: one of the most extensive and inclusive
  - 272 subject tags on each record
  - Some record has multiple subject tags
  - Source year: time series
- Time series expression: Movie is limited in
  - Resolution
  - Operation: playback speed, scene selection
- Still picture time series embedded


2011
2010
2009
2008
2007
2006
SOCIAL SCIENCES, INTERDISCIPLINARY
EDUCATION & EDUCATIONAL RESEARCH
SOCIOLOGY
SOCIAL ISSUES
COMMUNICATION
LAW
PSYCHOLOGY, SOCIAL
POLITICAL SCIENCE
ENVIRONMENTAL STUDIES
PLANNING & DEVELOPMENT
PUBLIC ADMINISTRATION
BUSINESS, FINANCE
AREA STUDIES
URBAN STUDIES
OPERATIONS RESEARCH & MANAGEMENT SCIENCE
SOCIAL SCIENCES, MATHEMATICAL METHODS
PSYCHOLOGY, MULTIDISCIPLINARY
ANTHROPOLOGY
WOMEN'S STUDIES
MULTIDISCIPLINARY SCIENCES
GEOGRAPHY
COMPUTER SCIENCE, THEORY & METHODS
COMPUTER SCIENCE, INFORMATION SYSTEMS
ENGINEERING, INDUSTRIAL
COMPUTER SCIENCE, CYBERNETICS
ECOLOGY
COMPUTER SCIENCE, HARDWARE & ARCHITECTURE
ARCHITECTURE
MATHEMATICS, INTERDISCIPLINARY APPLICATIONS
EDUCATION, SCIENTIFIC DISCIPLINES
MATHEMATICS, APPLIED
ENGINEERING, CIVIL
TRANSPORTATION SCIENCE & TECHNOLOGY
ENVIRONMENTAL SCIENCES
WATER RESOURCES
MINING & MINERAL PROCESSING
ENGINEERING, MULTIDISCIPLINARY
ENGINEERING, ENVIRONMENTAL
GEOSCIENCES, MULTIDISCIPLINARY
MATHEMATICAL & COMPUTATIONAL BIOLOGY
SOIL SCIENCE
AUTOMATION & CONTROL SYSTEMS
ASTRONOMY & ASTROPHYSICS
MINERALOGY
ENGINEERING, PETROLEUM
MATERIALS SCIENCE, PAPER & WOOD
ENGINEERING, MECHANICAL
REMOTE SENSING
IMAGING SCIENCE & PHOTOGRAPHIC TECHNOLOGY
ENGINEERING, ELECTRICAL & ELECTRONIC
ENERGY & FUELS
MATERIALS SCIENCE, CHARACTERIZATION & TESTING
MECHANICS
PHYSICS, MULTIDISCIPLINARY, FLUIDS & PLASMAS
NUCLEAR SCIENCE & TECHNOLOGY
PHYSICS, ATOMIC, MOLECULAR & CHEMICAL
CRYSTALLOGRAPHY
MATERIALS SCIENCE, BIOMATERIALS
INSTRUMENTS & INSTRUMENTATION
POLYMER SCIENCE
PHYSICS, APPLIED
PHYSICS, CONDENSED MATTER
SPECTROSCOPY
RADIOLOGY, NUCLEAR MEDICINE & MEDICAL IMAGING
CHEMISTRY, APPLIED
ENGINEERING, BIOMEDICAL
PSYCHOLOGY, CLINICAL
PSYCHIATRY
NURSING
BIOLOGY
OPHTHALMOLOGY
FOOD SCIENCE & TECHNOLOGY
CHEMISTRY, ORGANIC
RESPIRATORY SYSTEM
PHYSIOLOGY
PHARMACOLOGY & PHARMACY
IMMUNOLOGY
CELL BIOLOGY
BIOCHEMICAL RESEARCH METHODS
BIOTECHNOLOGY & APPLIED MICROBIOLOGY
OBSTETRICS & GYNECOLOGY
GENETICS & HEREDITY
PEDIATRICS
CLINICAL NEUROLOGY
GERIATRICS & GERONTOLOGY

Newly formed clusters

- Statistics reaching social issues
- Practical medicine disciplines and foundational bioscience are gathering to fight tumor
- Remote sensing, image science, automation control and aerospace engineering coming close; drone cluster?

Conclusions and beyond

- MDS+Jaccard Index works!

  Further plan
- Combine other processing / algorithm / data
- Update source data
- ...

references

- Forrest W. Young, “MULTIDIMENSIONAL SCALING”, http://forrest.psych.unc.edu/teaching/p208a/mds/mds.html
- Wikipedia, Matianus Capella, http://en.wikipedia.org/wiki/Martianus_Capella
- Aristotle, “Metaphysica” translated by Takashi IDE
- Kenneth Clark, “CIVILISATION: a personal view”, BBC TV programme

Thank you for your attention!