The Potentials of Cyberworlds -An Axiomatic Approach-

Tosiyasu L. Kunii, Dr. Sc.

Life Fellow of IEEE
Professor Emeritus of The University of Tokyo
Chief Technical Adviser of Morpho, Inc.
URL: http://member./acm.org/~kunii/
Old URL: http://wwwr.kanazawa-it.ac.jp/ITI/en/index.html
e-mail: kunii@ieee.org

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What are Cyberworlds?

- *Cyberworlds* are the worlds being formed in cyberspaces as computational spaces. Now cyberspaces are rapidly expanding on the Web either intentionally or spontaneously, with or without design.

Impacts and Potential of Cyberworlds

- *In e-financing that trades GDP equivalent in a day, we human beings living in the real world are at the stage of needing to firmly identify the nature of cyberworlds.*
- *We also note that **e-medicine** is becoming the core of health technology utilizing cellular phone-based imagery such as by Morpho Inc., through e-diagnosis and e-treatment.*

Cyberworlds Hardware Grounds

- The hardware grounds of cyberworlds have seen increasingly fast nonlinear shift from heavy to light.

Increasingly Fast Nonlinear Shift of the Computer Hardware Ground

-a brief chronological sketch-

- 1930-40: The Turing Machine and computability theory were developed by British mathematician Alan Turing in 1937. This is known as Alan Turing's mathematical abstraction of computability.
- 1943-46: Vacuum tube-based ENIAC was built at Moore School of Electrical Engineering of the University of Pennsylvania by John Mauchly and J. P. Eckert.
- 1948: William Bradfield Shockley invented transistors at Bell Telephone Laboratories.
- 1964: IBM 360 dominance of mainframes started.
- Mid 1970: UNIX by Dennis Ritchie and Kenneth Thompson at Bell Laboratories initiated the emergence of minicomputers and workstations.
- 1980: Patterson and Ditley at the University of California, Berkeley invented RISC.
- 1987: SPARC architecture machine by Sun Microsystems, a derivative of RISC II machines of Patterson and Ditley, have taken 58.8 % share in the workstation market in 1991. MIPS was developed by Hennessey at Stanford at the same time.
- 1990-: The Intel and Microsoft dominance of PC (personal computer) market share has been leading the world computer industry.
- 2005-: Cellular phones are taking over PC in Web browsing and e-mailing, and also surpassing digital cameras in daily photography.

The Rigorous Characterization of Cyberworlds

- Rigorous characterization based on axioms and theorems as in mathematics and physics.

Axioms

- **Axioms**
- **Axiom 1 The *power* area *size* (namely, the size of the major area of a given great power) is in proportion to the information speed (namely, the speed of the information made available to the power).**
- **Axiom 2 The *power period* is in inverse proportion to the information speed.**
- The *Time Period* Considered: From the Egyptian Dynasties to the current world, namely from 3,100 BC to 2,000 AD.
- The *Initial Power Area:* The Mediterranean Sea and the surroundings containing Cairo, Athens and Rome with the size of about 2 million km^2.

The great power shift from 3,100 BC to the future

The Great Powers	Information Carrier	Information Speed	The Power Area Size	The Power Period
Pax Romana	human feet networks	5 - 10 km/hour	2 million km^2	1000 years
Pax Britanica	surface vehicle networks	50 - 100 km/hour	20 million km^2	100 years
Pax Americana	aircraft networks	500- 1000 km/hour	200 million km^2 (40 % of the whole globe surface)	10 years
Pax Informatica	Computer networks	0.5 billion km/hour	500 thousand times of the whole globe surface	5 minutes

The axioms are validated as the first order abstraction of the human history.

Theorem

- Theorem as Prediction:
- Nonlinear, and quality dominate the world power shift in the cyberworld era.

The Nature of Cyberworlds

- Now, for the first time in the human history, it is not the quantity but the quality that takes the lead and will be the master of the stage and scenes of the real world.
- Computer networks have linked the world at the information speed enough for any power to have a power area size far beyond the whole area of the globe,
  - but with a momentary power period making *the global world economically unstable* as Soros* has pointed out.

*George Soros, "The Crisis of Global Capitalism -Open Society Endangered-", Public Affairs, New York, 1998.

Winning Media of Cyberworlds in Hardware

- Cellular phones

  Far beyond communication media

  1. Computers
  2. TV such as 1 seg

  Approx. 4.806 million mobile phones were sold in Japan in November 2007. Of these, approx. 3,054 million phones, 63.5% of the total, can receive 1seg broadcasts.

  3. Purses and credit cards to pay
  4. Cameras
  5. Information managers

Architecture of Cyberworlds

- Cyberworlds are virtual and real, and the most versatile, general and generic, requiring matching framework for architectural design.
- As such, topology is known to be most abstract and generic. For topology to be computable, it has to be algebraic, hence is algebraic topology.

Architecture of Cyberworlds –continued-

- Extremely large volume and fast evolution of information of cyberworlds require generic information characterization architecture.
- The best candidate is differential topology, Morse Theory and Reeb graphs in particular. They are proven to be very useful for characterization of imagery as we implemented as critical point filters (CPF)*

* Unconstrained Automatic Image Matching Using Multiresolutional Critical-Point Filters", Yoshihisa Shinagawa and Tosiyasu L. Kunii, IEEE Transactions on Pattern Analysis and Machine Intelligence, Vol. 20, No. 9, pp. 994-1010, September 1998.

Differential Topology Applied to Images

- Taking the gray scales as the height functions, differential topology are immediately applicable to characterize images to yield remarkable results.

An Incrementally Modular Abstraction Hierarchy (IMAH)by Algebraic Topology

- The considerations of abstraction levels explained so far for an incrementally modular abstraction hierarchy .
- The adjunction spaces model the common properties of dominant commercial information systems being used by major private and public organizations by abstracting the common properties to be equivalent among different information systems as adjunction spaces.
- Adjunction spaces thus serve as a novel data model that can integrate information systems linearly and hence *avoiding the combinatorial explosion* of the integration workload.

IMAH –continued-

- For automated linear interface generation after the linear integration at the adjunction space level, we use the *incrementally modular abstraction hierarchy* as shown below such that we are interfaced to existing information systems to the extent we realize linear interoperability to perform the integrated system-wide tasks.

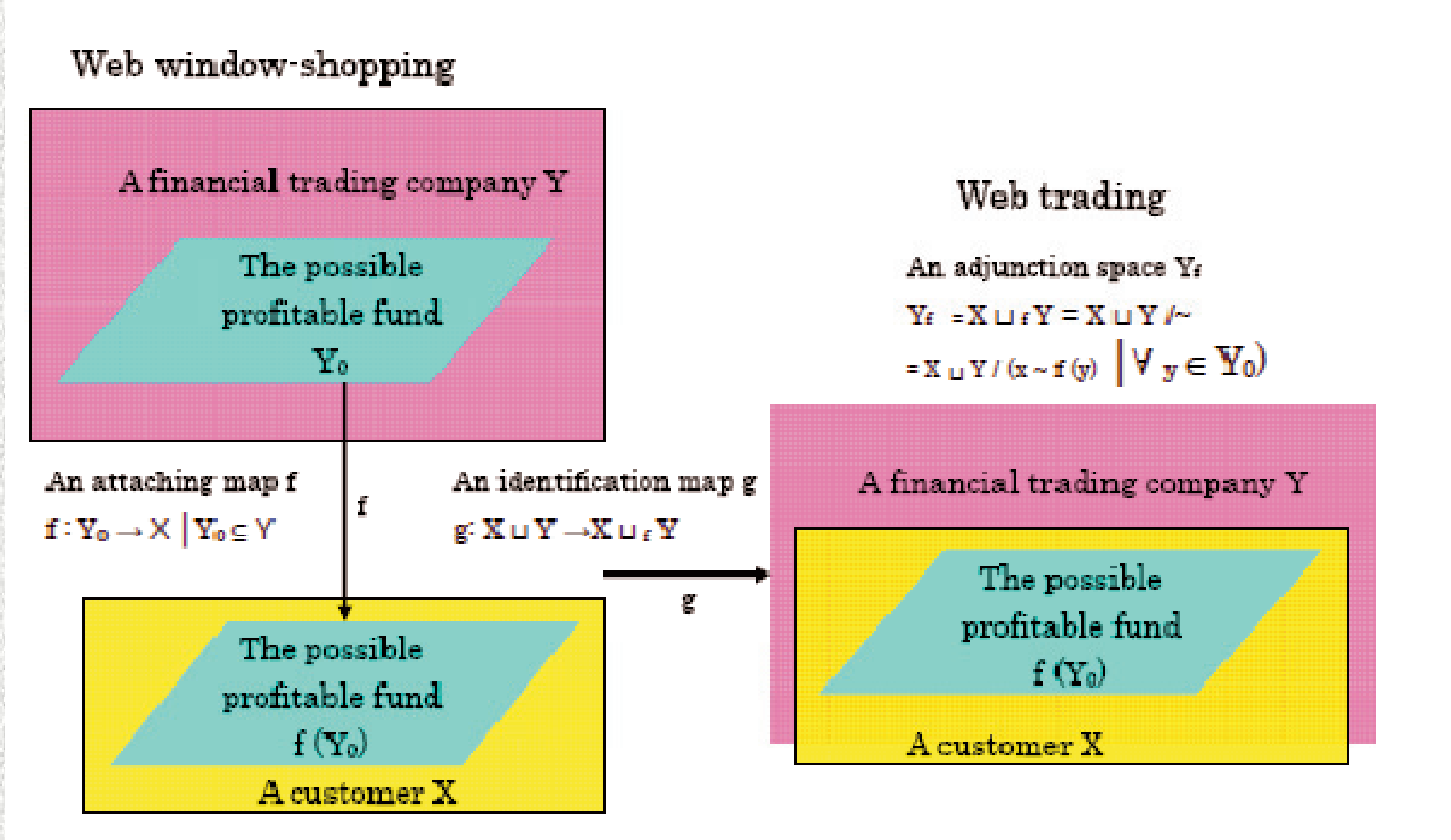
IMAH –continued-

- 1. The homotopy level;
- 2. The set theoretical level;
- 3. The topological space level;
- 4. The adjunction space level;
- 5. The cellular space level;
- 6. The representation level;
- 7. The view level.

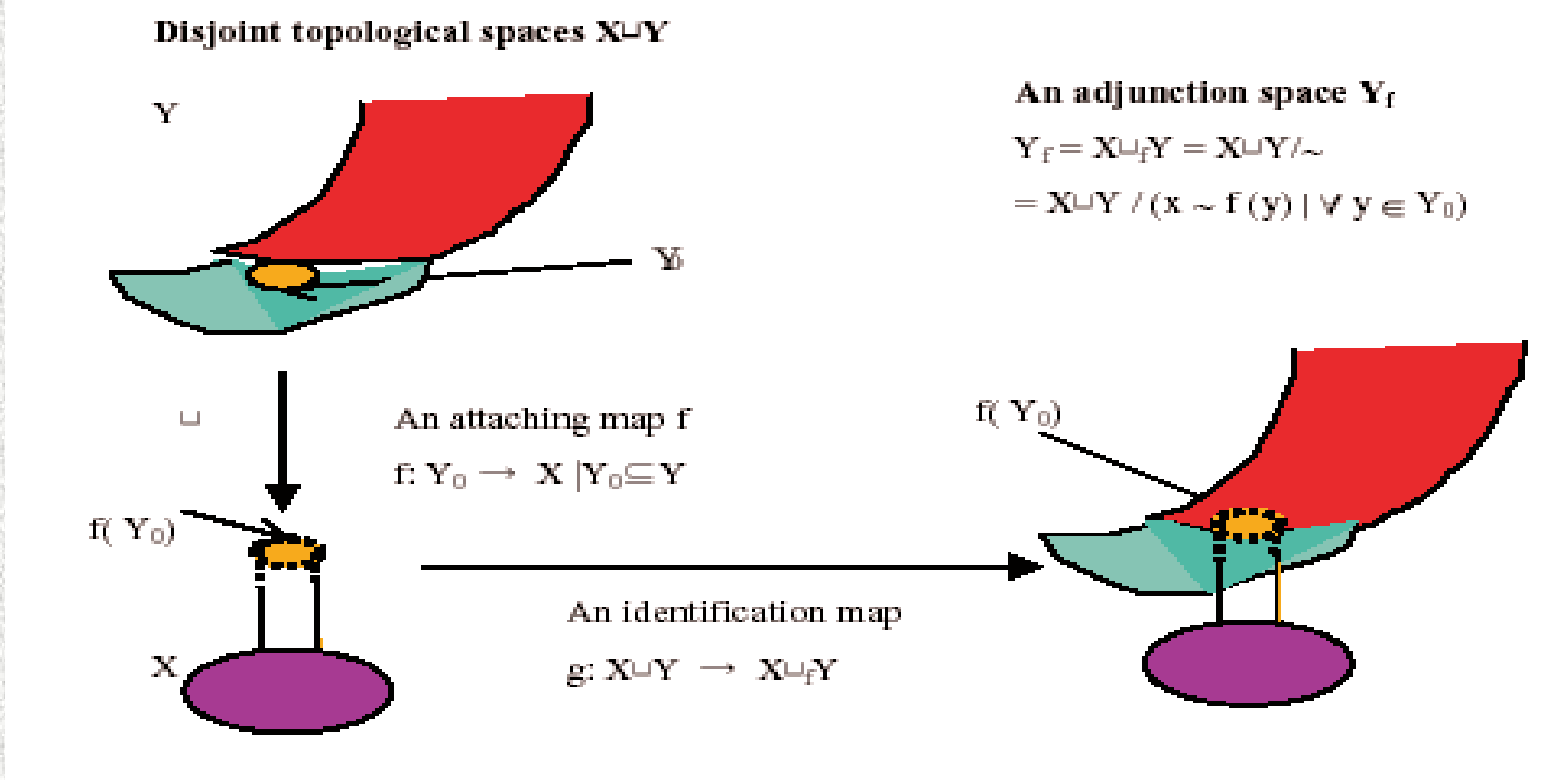
The Major Key Players of Cyberworlds

- e-finance that trades a GDP-equivalent a day.
- e-manufacturing that is transforming industrial production into Web shopping of product components and assembly factories.

Financial trading processes on the Web



e.g. e-manufacturing: a simple example



Differential Topological Design

Morse theoretical model and Reeb graph ***model***

- Definition A critical point x of f is called *nondegenerate* if d^2f is *non*degenerate at that point. This is equivalent to the condition det $d^2f \neq 0$ at x. The *index* of x is the index of d^2f at x. The *nullity* of x is the nullity of d^2f at x.
- These definitions do not depend on the choice of a local coordinate system. In this paper we will deal mostly with nondegenerate critical points.
- Definition A smooth function on a smooth manifold is called a *Morse function* if all its critical points are nondegenerate.

Nondegeracy

- It can be proved using Sard's theorem that Morse functions exist on any smooth manifold. In fact, any smooth function on a smooth manifold can be approximated as closely as desired by a Morse function. Nondegenerate critical points are *isolated* (that is, there cannot be a sequence of nondegenerate critical points converging to a nondegenerate critical point); in particular, a Morse function on a compact manifold has only finitely many critical points, and they are isolated.

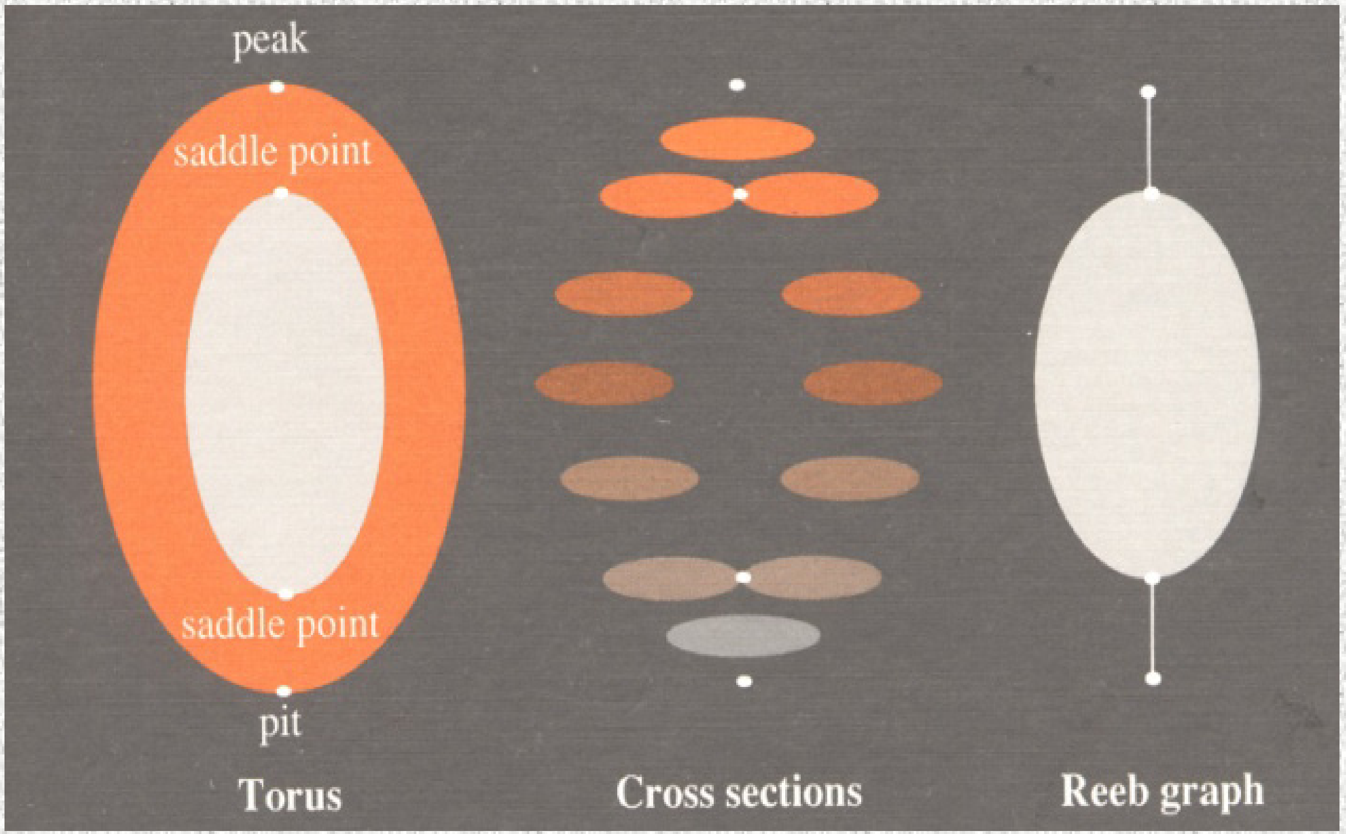
Nondegenerate Critical Points

- The fact that nondegenerate critical points are isolated follows from this result. which is proved in, for example:
- Lemma (Morse's Lemma). *If* x_0 *is a nondegenerate critical point of a function f on a manifold M, there is some open neighborhood of* x_0 in M *and a set of local coordinates* $x^1, \ldots, x^n$ *such that, in these coordinates, f has the form*
- $f(x) = f(x_0) - (x^1)^2 - \ldots - (x^\lambda)^2 + (x^{\lambda+i})^2 + \ldots + (x^n)^2$, *where λ is the index of the critical point.*
- Thus, it is always possible to choose local coordinates in the neighborhood of a nondegenerate critical point so that the function in this neighborhood is a diagonalized quadratic function when expressed in these coordinates. Note that we are dealing here with an exact equality: there are no additional higher-order terms.

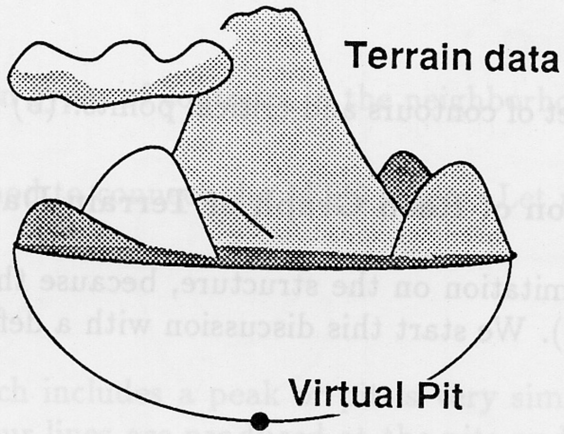
The Morse Lemma and the Reeb Graphs

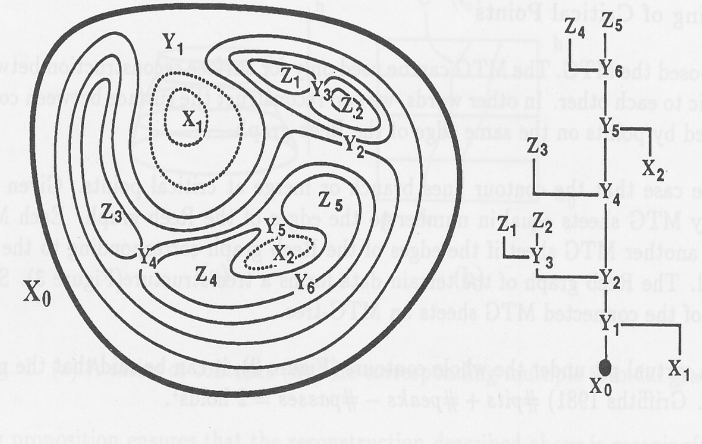
- The Morse lemma and the Reeb graph are powerful tools to abstract the characteristics of 3D shapes in differential topology. The figures in the following slide show some examples. Kergosien has been pioneering researches in this area including medical applications

A Simple Example of a Torus to Abstract the Characteristics of 3D Shapes by the Morse Lemma and the Reeb Graphs



An Example of a Terrain to Abstract the Characteristics of 3D Shapes by the Morse Lemma and the Reeb Graphs





(a) (b)

Dynamic Image Generation by CPF

The initial image

The final image

A CPF Generated Dynamic Image

Res.mpg

Cyberworld for Information & Health Technology, Joint Lab of Health Information Technology

- IMAH and CPF play critical roles to set the architecture and realize high performance.
- Implementation on cellular phone-based systems is clearly most advantageous and should be pursued.
- All require high level knowledge and experiences, making it most adequate for Joint Lab of Health Information Technology, High Performance Computing Center, Shanghai University, and Morpho Inc. as a venture of The University of Tokyo at The University of Tokyo Entrepreneur Plaza.

Thank you so much!
Q&A

- 太感谢！[tài g ǎ nxiè]
- 疑问 [yí wèn]