Plenary Lecture

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Innovation Science

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Intelligent Systems Laboratory

Outline

- Innovation definition
- Examples of innovation rules
- Innovation science
- Data and innovation
- Innovation case studies
- Conclusion

Basic Research Questions

- To what degree is Innovation an art or a science?
- Can the science base of innovation be established?
- What elements of innovation can be taught?
- What methodologies/computational tools can be developed in support of innovation?
- What type of work environments foster innovation?

Why Innovation Science?

Main Drivers

- 50% of US economic growth attributed to innovation
- Strong differentiator of US economy in the 21st century
- Innovation can easily override almost any other improvement that we could possibly make
- Success of entrepreneurship programs

Innovation Approach Example: Boeing Co.

Large Scale Problem

- Why do we fly the way we do?
  - Passenger processing
  - Handbags processing
  - Main luggage processing
  - Plane loading and unloading
- Can we do better?
- Systems of systems solutions

Innovation Approach Example: HP Co.

Small Scale Problem

- What should a printer do besides printing (e.g., faxing)?
- What functionality should it have?

Innovation Tools

Example

- Brainstorming can be done WELL and POORLY
- What about more serious tools supporting innovation?
- Who knows about these tools?
- Who will develop them?

Innovation Science Perspectives (1)

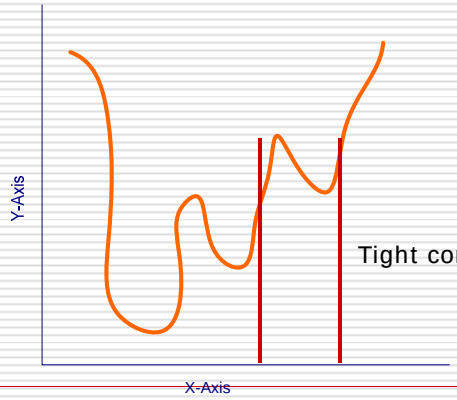
"Borrowing" from

- Mathematical programming
- Evolutionary computation
- Data mining

Innovation Science Perspectives (2)

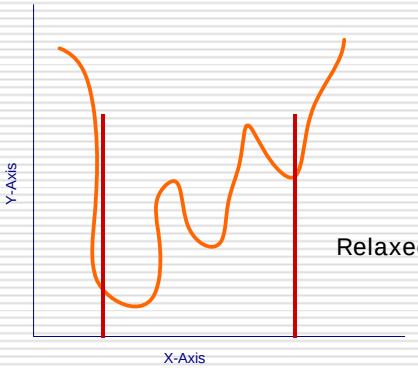
Find the minimum!

Example

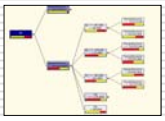


Innovation Science Perspectives (3)

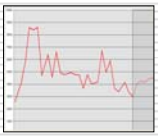
Constraint relaxation



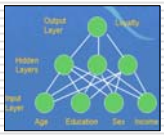
Data Mining Algorithms


Decision Tree

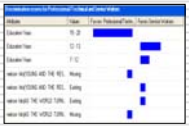

Clustering


Temporal analysis


Association



Neural network


Bayesian network

Knowledge

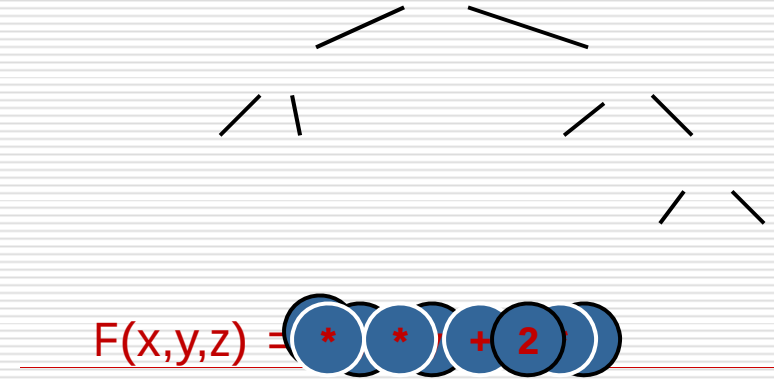
Innovation Science Perspectives (4)

- Evolutionary computation, e.g., genetic programming
  - Based on natural systems
  - "Smart" exploration of alternatives

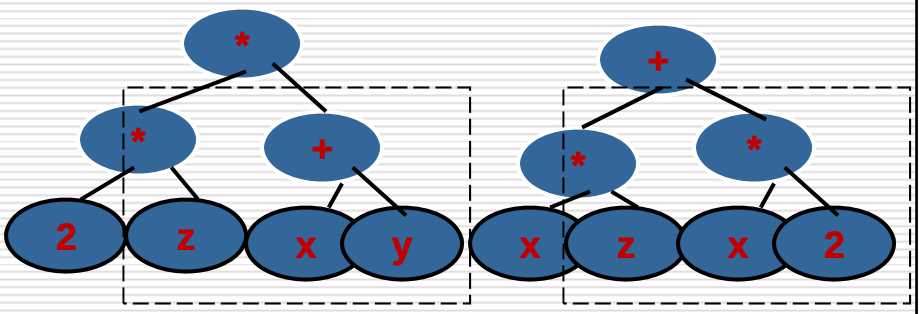
Example: Design without patent infringement

GP Representation

- Designs are represented as trees



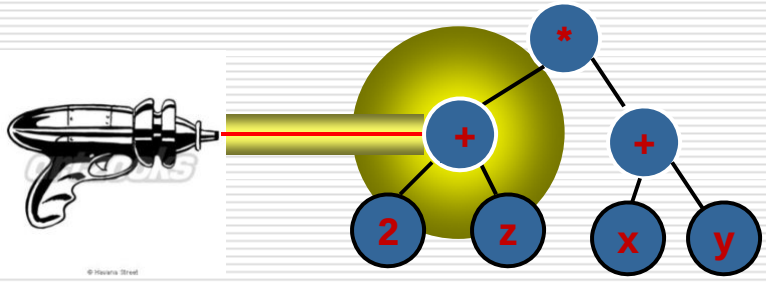
Crossover



Design 1

Design 2

Mutation

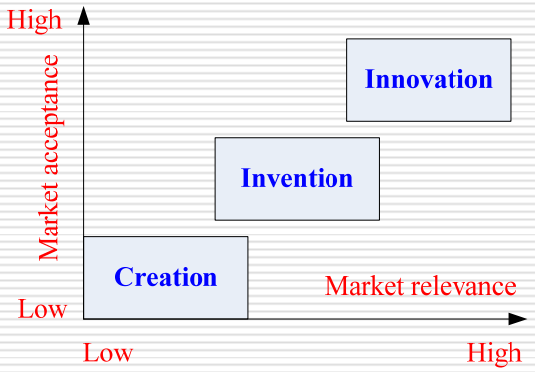


Innovation Environment: Definitions

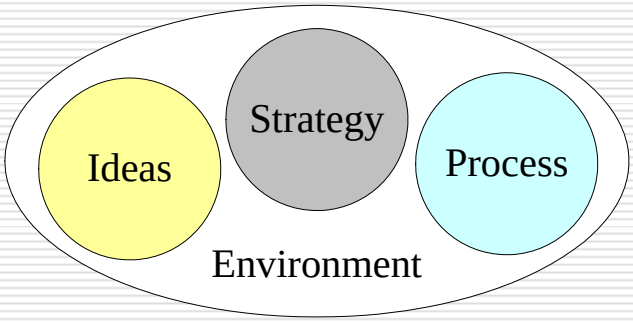
Business incubators
Entrepreneurship
Leadership

Creativity → Invention → Innovation → Innovation Facilitators

Relationship between Creation, Invention, and Innovation



Innovation: What is Needed? (1)



http://www.getfuturethink.com

Innovation: What is Needed? (2)

- Ideas: Consider many alternatives
- Strategy: Setting goals and ways of achieving them
- Process: Establish basic innovation steps
- Environment: Making innovation a natural activity

Innovation: A Question

- Where to focus:
  - Generating new inventions?
  - Transformations of existing solutions into innovations?
  - Integrating existing inventions into innovations?

Radical innovation

Continous innovation

Integrative innovation

Innovation in the Literature

- Creativity
  - Book ***The Creating Brain: The Neuroscience of Genius*** by Nancy Andreasen, U of Iowa Professor of Psychiatry
  - Andreasen's Theory (Hypothesis): "Creative ideas appear spontaneously when people are not trying to be creative"
  - Example 1
    - Mozart who composed his music after a good meal and a walk, that would occasionally trigger a complete symphony

Innovation in the Literature

- Creativity
  - Example 2
  - Friedrich Kukule – German chemist who determined the structure of benzene - entered a dreamlike state in which the form of benzene came to him in a brilliant flash

Innovation in the Literature

- Creativity
  - Terrence Ketter – Professor of Psychiatry, Stanford U
  - Ketter's Theory (Hypothesis):
    "Creativity is directly related to mental instabilities, because the brain uses its negative emotion to initiate a real or fictional solution to the problem"
  - What comes first creativity or the mood disorder?
  - Where does creativity comes from? [It is not known, Peggy Nopoulos, UI Professor of Psychiatry]

Innovation in Industry: SRI

- Innovativeness
  - Book ***Innovation: The Five Disciplines for Creating what Customers Want*** by Curtis Carlson, CEO, SRI International, Menlo Park, CA and William Wilmot, Director, Collaboration Institute
  - Hypothesis: "Rapid, consistent innovation comes from highly disciplined processes" [which may surprise many]

Innovation in Industry: SRI

- Innovativeness
  - Five disciplines:
  1. "Select important, not merely interesting problem"

     E.g., Douglas Engelbart, the SRI engineer who invented the computer mouse and hypertext, asked his team "to make the world a better place by augmenting and extending the human intellect"

Innovation in Industry: SRI

- Innovativeness
  - Five disciplines:
  2. "Assess each innovation for its value to the customers"

     Look beyond cost and quality, e.g., into convenience and conscience
  3. "Appoint a champion who is insanely committed to the project"

     No champion, no project, no exception

Innovation in Industry: SRI

- Innovativeness
  - Five disciplines:

    4 & 5. "Building teams and doing so across the organizations"

    Engelbart's iterative approach was also applied on a larger scale by Google, which publishes beta versions of its products and feeds customer responses into development of these products

Innovation in Industry: Xerox

- Combine Ideas

  Xerox Corporation looks for intersection between ideas and combining them into next offering of products

Innovation in Industry: Xerox

- Create an Internal Incubation Fund

  Xerox sets aside funds that encourages employees to network and develop ideas that are different from the currently funded ones

Innovation in Industry: McDonald's

- McDonald's innovation team thinks it terms of "back-casting" – starting with an end-product and working backward towards the basic idea that is cost and technology feasible

Innovation in Industry: McDonald's

- Do Rapid Prototyping

  McDonald's transforms quickly ideas from a blackboard to 3-D models

Innovation in Industry

- Take it On-Line

  Idea management software automates the innovation process by allowing multiple partners to contribute to the idea being worked on

Innovation in Industry

- Take advantage of "gift economy"

Examples

- Wikipedia
- Linux operating system
- Firefox web browser
- Media sites: Facebook, Flickr

Innovation in Industry

- Allan Morally – Ford's CEO
  - Innovation rule at Boeing
    - Encouraging managers to speak up about problems (not prize him and themselves for the job well done as commonly recommended, e.g., D. Trump – a business person has to be always positive)

Innovation in Industry

- Carlos Ghosn's Innovation Ideas
  - Sell-off Nissan shares to the suppliers
  - Forming world-wide alliances
  - Pursuing the concept of common platform across continents
  - Micro managing, as needed.

Innovation in Insurance Industry

- Pay As You Drive"™ insurance is a new type of car insurance providing comprehensive individual cover
- Using the GPS (Global Positioning System) technology monthly insurance premium is calculated based on driving pattern of an individual driver

http://www.payasyoudriveinsurance.co.uk/index.htm

Different Thinking

- All businesses require innovation driven by new ideas. Some degree of unconventional thinking is essential for businesses to succeed
- Experience points to many companies trapped in conventional thinking

Innovation and Globalization (1)

- At present emerging markets make over 20% of the global economy
- 25 years from now emerging markets will make up at least 50% of the global economy
- In the past 20 years US exports to emerging markets have increased 338% (much faster than domestic demand)

Innovation and Globalization (2)

Industrial Examples

- GE is expanding in the emerging markets
- Goldman Sachs builds franchises in China
- Dell and GM increasingly produce in India and China for local markets

Innovation and Globalization (3)

Culture Change

- P&G
  - Places young manages with local families
  - Establishes international focus groups to tailor products to local markets
  - Forms business alliances with new breed of companies

Innovation and Globalization (4)

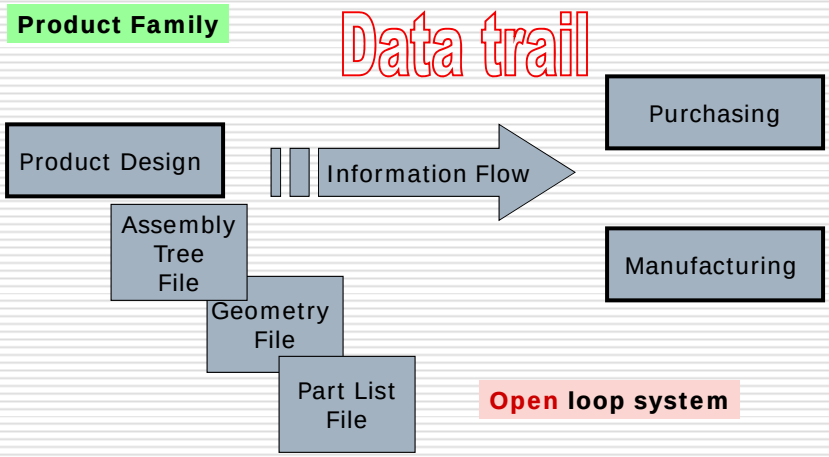
Culture Change

- Universities
  - Emphasize teaching creative problem solving skills
  - Introduce programs of study and work abroad
  - Promote learning foreign languages

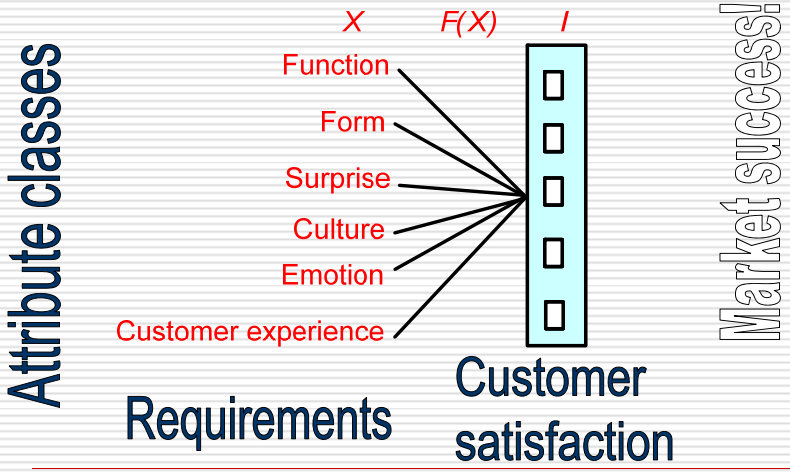
Data-driven Innovation

- Data reflects product/system behavior
- Data has been used to monitor, processes, improve efficiency, detect faults, and so on
- The use of data in innovation has not been sufficiently pursued
- Innovative ideas may embedded in the data

Traditional Design



Modeling Innovation

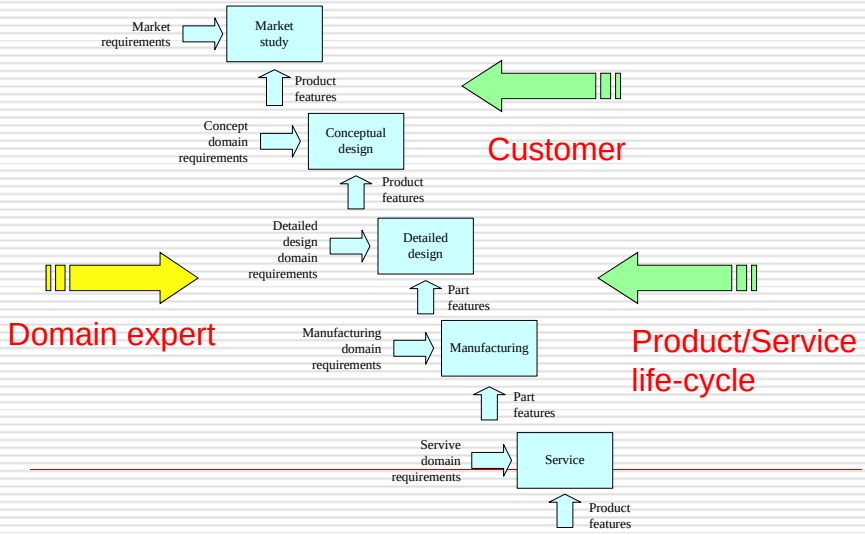


Innovation: Multi-dimensional Origin

- Customer induced
- Expert induced
- Product life-cycle induced
- Information-world induced

- Requirements driven

Dimensions 1, 2, 3: Requirements Flow



Customers Involvement

Example

- Procter & Gamble has opened its product development processes to key stakeholders
- Innovation success rate has doubled in two years
- R&D expenditure has decreased by 3.4%

Domain Expert Involvement

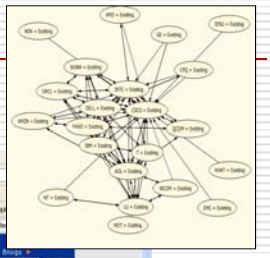
Example

- Clinicians often administer drugs for cases that are not indicated on the label.
- In chemotherapy, the off-label use of drugs as much as 85% of the total prescriptions.
- 29 new approved drugs studied.
- In five year period after the drugs have been introduced to the market, 143 new applications were identified.
- Eighty-two (57%) of the 143 drug therapy innovations in the studied sample were discovered by practicing clinicians through field discovery.

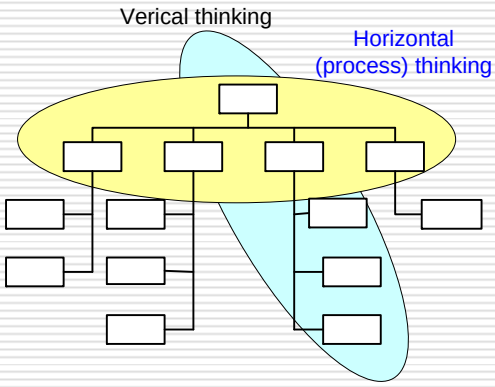
Dimension 4: Cyberspace

Example

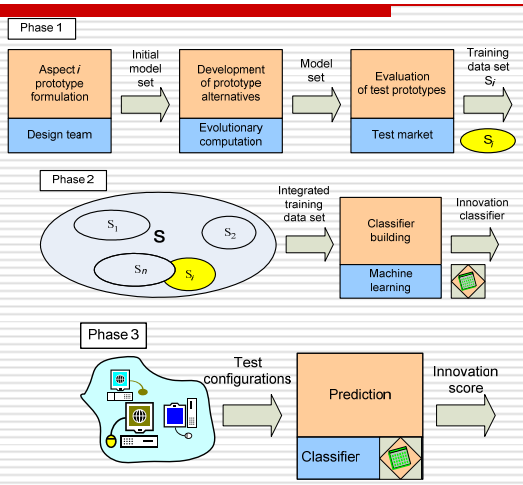
MySpace



Innovation: Process Thinking



Innovation: A Data Mining Solution



Challenges

- Data availability
- Industry struggle with embracing the concept of gift economy
  - Benefits from customers' input
  vs
  - Potential losses from revealing
- Lack of experience
- Computational experience with mass customization data

Summary

- Innovation handled at the business-rule level
- Data may change the innovation landscape
- Evaluation of products/services the most important gap
- Great promise of the innovation-driven economy
- Diverse products, systems, and services call for different innovation approaches

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