**Research Perspective & Challenge**

研究的智慧– 问题·方法·挑战

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- Research fundamentals
  - What, why, how?
  - Research methodology
  - Research training & evaluation
- Success for research
- Key elements in writing a paper?
- Challenge in the new age
- Blue Research

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**From Wealth to Power – built to last**

Short term

Long term

Human/Nature environment

System

Education

Culture

…

2010年12月21日星期二
University & Research

Two tasks in University: education/research

- Producing talents for creation
- Creating new knowledge

Innovation/creation requires research

Environment: academic freedom

- Origin of democracy/paradise for justice
- Good for talents/knowledge growth

Operation Principle

Future

Talents

Education/Research

Academic Environment

Present
Research Difference in Academia & Industry:

Research: transform money into knowledge

Focus – why/ how?
Background – mathematics/ physics
Solution – long term/ short term
Value – intangible/ tangible
Staff – best (global)/ suitable (local)

Innovation: transform knowledge into money

Applied research
Different Innovations

R&D in industry - product
Physics

Mathematics

Pure research

Applied research

3 “misleading”
• Useless
• Paper only
• Math only
Relationship

Physics

Short-term

Product

Applied research

Fundamental research

Mathematics

Long-term

Industry

University in China

Example – apple tree (apples and roots)

Example – Control of Electro-Magnetic Platform

EM xy-motion table

Accurate model of EM xy-table

Control

Applied research

A generic motor driven xy-table

modeling

control

A generic EM driven xy-table

modeling

control

Fundamental research

Not urgent

Urgent

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How to start Research?

3 key elements:
- Problem
- Problem
- Problem

Unique, significant, useful

- Literature survey
- Experimental analysis

Science exists everywhere

Research Perspective

Math/tech → physics → philosophy → religion → Life

Spirit world

Physical world

E = mc²

Idealism 唯心论

Materialism 唯物论
Research Methodology - I

• **Top-down approach (pure)**
  Define a problem,
  Method/theory development,
  Application to a well-selected case;

High-level theoretical development

Low-level technical realization

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Example – 3D Fuzzy Logic System

**Problem 1: A complex stochastic process**

Modeling philosophy under time-varying stochastic complexity
Example – 3D Fuzzy Logic System

Problem 2: Distributed parameter systems

\[ \frac{\partial x(z,t)}{\partial t} = \frac{\partial^2 x(z,t)}{\partial z^2} + b(z)u(t) \quad t > 0 \]
\[ 0 < z < 1 \]

Boundary conditions

\[ \frac{\partial x(z,t)}{\partial z} = 0 \quad z = 0 \]
\[ \frac{\partial x(z,t)}{\partial z} = 0 \quad z = 1 \]

Initial condition \[ x(z,0) = x_0(z) \]

Existing Fuzzy Logic System

**Rule** \[ \text{if } x_1 \text{ is } A_{1j} \text{ and, } \ldots \text{ and, } x_n \text{ is } A_{nj} \text{ then } y \text{ is } B_j \]
**Limitation – 2D function**

Feature - two-dimensional (2D) fuzzy set

in incapable to handle 3-domain process

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**Methodology Development**

3-Domain Design

- Inherent capability to process extra degree of freedom
- A little complexity increased from the traditional fuzzy system
- Rules will not increase as sensors increase
Method 1: 3D Probabilistic Fuzzy MF

Appearance in 3-dimensions
Projection in 2-D: A primary MF and its secondary PDF

Probabilistic Fuzzy Logic System (PFLS)

Rule j: If $x_1$ is $\tilde{A}_{i,j}$ and $x_2$ is $\tilde{A}_{2,j}$ ... and $x_n$ is $\tilde{A}_{n,j}$ Then $y$ is $\tilde{B}_j$

Method 2: 3-D Spatial Fuzzy MF

\[ V = \{(x, z), \mu_T(x, z) | \forall x \in X, z \in Z\} \quad 0 \leq \mu_T(x, z) \leq 1 \]

Spatio-temporal fuzzy logic system

Research Methodology - II

• **Bottom-up approach (applied)**
  Given an actual case – study and understand it
  Formulate it into a theoretical problem
  Methodology development for the theoretical problem
  Approximate application to the given case;

  ![Diagram of research methodology](image)

Example – Control of laminar cooling

1) **Industrial case** - Technical appearance

2) **Problem definition** - Functional appearance

![Diagram of control of laminar cooling](image)
Example – Control of laminar cooling

3) Methodology development

4) Application results

IEEE Transactions on Control System Technology, 9(2), 348-356, 2001

How to evaluate Research?

3P -- paper, patent, proposal

Influence impact

Quantity

Quality – impact factor, citation, ....

Applied nature
Research Training – 3 phases

- Basic/technical level:
  Find the solution for a given problem;
- Research level:
  Identify problems in a given field;
- Professor level:
  Able to explore new research area;

Math-oriented (continuous)
纵向思维

Art-oriented (abrupt)
横向思维

Requirement for Research Work

- Technical solid/depth (看不懂)
- Deep understanding (问不倒)
- International publication – essential requirement
Who suitable for PhD?

Work style
- Industry – being asked what to do / daily pressure
- Academia – figure out what to do / long-term challenge

Personality
- Industry – working with people
- Academia – work independently

Career development
- Industry – CEO → management/money
- Academia – professor → research/freedom

Peter Principle
Laurence Johnston *Peter* (1919–1990)

Employees within an organization will advance to their highest level of competence and then be promoted to and remain at a level at which they are incompetent.

A good student will eventually advance to a level at which he becomes mediocre.

Not everyone suitable to ……

In mid 1940, Goldman hired a young man,…
Research Students Requirement

3 key elements for students

- **Knowledge background** - Mathematics
- **Intelligence** – genetically inherited
- **Diligence** – 10,000 hour rule

![Diagram showing Diligence, Knowledge, and Intelligent Quotient]

Example – Einstein: IQ=150,
Chris Langan: IQ=195;

Story: Dog/rabbit;

Survival Triangle

**Society** ⇒ safety, living, education, medical

**Work** ⇒ insecure

**Person** ⇒ over-loaded

**Success triangle**

- **Adversity Quotient is key**
- It can be learned;

- **Emotional Quotient**
- **Intelligent Quotient**
Ideal & Reality

In 1830 in Europe, a rich man died who was born in poor, he left a will to award a word for success…..

野心

Everyone has a good wish – an ideal (理想) or dream, it is not ambition unless…..

Success is a habit

3 keys in mind development that can transform ideal into ambition

• Desire
• Faith
• Attitude

More examples …..
Example

Illinois Institute of Tech

The Sermon & the Institute

In 1890, when advanced education was often reserved for society’s elite, Chicago minister Frank Gunsaulus delivered what came to be known as the "Million Dollar Sermon". From the pulpit of his South Side church, near the site Illinois Institute of Technology (IIT) now occupies, Gunsaulus said that with a million dollars he would build a school where students of all backgrounds could prepare for meaningful roles in a changing industrial society. Philip Danforth Armour, the Chicago meat packer and grain merchant, heard Gunsaulus' sermon and came to share the minister's vision. He agreed to finance the endeavor with the stipulation that Gunsaulus become the first president of Armour Institute.

A book – “A Message to Garcia”
Elbert Hubbard, 1899

• In 1898, US started a war with Spain to free Cuba.
• American president must send a message to General Garcia in Cuba;
• Rowan took the letter and did not ask any questions, and completed the task.

Where to find such a person who will send a letter to Garcia?

Four different types of personality

Type 1 - Person who has completed the work before being asked
Type 2 - Person who will complete the work after being asked
Type 3 - Person who will start working after a push
Type 4 - Person who will not work even after a push

Where are they?

Type 1 – Top and distinguished in every field, they are leaders.
Type 2 – Most of them are in middle class and good followers.
Type 3 – They are reluctant to do anything and always have complaints
Type 4 – Most of them are unemployed
Example – A Clear Target

Ideal ⇒ Target ⇒ Ambition ⇒ Success

An interesting study to investigate high school students in US

- About 10% has a clear goal
- About 80% has vague idea
- About 10% has no goal

20 years later:
- Top in the society
- Middle-class
- Unemployed

Success is a Habit

Thinking ⇒ Life

Think and Grow Rich
Napoleon Hill, 1937

Desire, Faith, Attitude

E = mc²

Seeing is believing ⇒ believing is seeing

Root flower

Spirit world

Unlimited Power

Positive source

Everything possible

Success

Physical world

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Success Rules

- 潜意识信念的力量 - 意念成就事实
- 燃烧欲望的力量 - 愿以生命去赌必成功
- 明确目标的力量 - 可以拥有任何你想拥有的东西
- 信心的力量 - 想象并相信美梦必成
- 坚持的力量 - 成功是多次努力的结果
- 行动计划书的重要 - 列出所有可能的方法
- 特殊知识的力量 - 知道答案在哪里, 及如何找到
- 诚实的力量 - 所作所为, 最后都会作用到自己
- 宽厚的力量 - 帮助别人, 就等于帮助自己

Why Paper?

Paper convey idea from your head to reader’s head

Gain recognition, impress others

- Writing logic ≠ Doing logic
- Show details clearly for reader easily to understand and copy
Paper Structure

• Abstract
• Introduction
• Problem description
• Idea & solution
• Details for development
• Demonstration (experiment/simulation,…)
• Conclusions

Paper Structure - 2

• Abstract (a few sentences, written last)
  – State the problem
  – Why it is interesting
  – What & how your solution achieves

• Introduction (1-2 pages)
  – Describe the problem
  – Literature survey to show what unsolved, why important
  – State your solution

• Conclusion (0.5 page)
  – List all your contributions
How to write a research paper?

- **Realize its importance** (spiritual)
- **3 key elements** (physical):
  - Originality/significance/contribution
- **Others:**
  - Technical content – correct/solid/length
  - Readership – wide interest
  - Presentation – easy to read (structure/figure/text)
    - References – complete survey

How to write a research paper? for foreign English writer

**Logic** is first important – Every paper has its theme, each section has its idea, so does each paragraph;

  Problem is often hidden

**Structure** to be well organized

  Figure/table can speak
  Use simple English sentences

**Simplicity** is beauty;

  Math is to rely less on math.
  For beginners, first long \( \Rightarrow \) then short

A good paper is an art
When revising paper

- Respect your reviewers!!!
  - Calm down to study questions carefully and understand the true meaning of every question – this may take you a lot of time;
  - Write a nice response to answer their questions – this will take you most of time;
  - Seriously consider reviewer’s comment to revise paper
- Good attitude and effort !!!
  - My survey paper: 58 revisions in 2yr, 3 trials in 1.5y
  - First paper in ASME: 3 trials

10% success rate for the top journal!

Challenge in Information Age

- Population -> Economy -> Life
- Impact to Academia
- Blue ocean strategy – innovation to success
Challenge

Hunting → agriculture → industrialization → knowledge → intelligence

<table>
<thead>
<tr>
<th></th>
<th>Old Age</th>
<th>New Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pace/speed</td>
<td>Low</td>
<td>high</td>
</tr>
<tr>
<td>Degree</td>
<td>Low/less</td>
<td>high/more</td>
</tr>
<tr>
<td>Knowledge</td>
<td>less</td>
<td>more</td>
</tr>
<tr>
<td>Imbalance</td>
<td>Low</td>
<td>high</td>
</tr>
<tr>
<td>Opportunity</td>
<td>more</td>
<td>Less?</td>
</tr>
</tbody>
</table>

Population Growth
## Life

<table>
<thead>
<tr>
<th></th>
<th>Old Age</th>
<th>New Age</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Competition</strong></td>
<td>Low population, shorter life; ⇒ more work/less people;</td>
<td>high population, longer life; ⇒ less work/more people;</td>
</tr>
<tr>
<td><strong>Security</strong></td>
<td>Secure job &amp; retirement;</td>
<td>Insecure job &amp; retirement;</td>
</tr>
<tr>
<td></td>
<td>Good welfare;</td>
<td>Poor welfare;</td>
</tr>
<tr>
<td><strong>Life style</strong></td>
<td>Work for money</td>
<td>?</td>
</tr>
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The World is Flat & Curved


3 main forces ⇒ small transparent world (complex)

- Global political environment;
- Internet (hardware/software/management)
- BRIC population ⇒ market

• Globalization: opportunity everywhere for everyone
  multi-national/discipline cooperation, Mixed identity,

• Long tail effect

• M-society: opportunity not equal to everyone

Long Tail Effect

Chris Anderson, 2006

break 20/80 principle

From hits to niches

Lengthen the tail (more things)

Fattens the tail (more access to niches)

Bad: drowned in information

Good: individual = group

Survival: cut the tail

opportunity for everyone

Find niches

Lengthen the tail

Fattens the tail

from hits to niches

break 20/80 principle

variety

strength

lengthen the tail

Fattens the tail

Cut the tail

Find niches

From hits to niches
Resource Management

20-80 principle

The 7 Habits of Highly Effective People, Stephen R. Covey, 2004

<table>
<thead>
<tr>
<th>Important</th>
<th>Not urgent</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>II</td>
</tr>
<tr>
<td>Urgent</td>
<td>Not urgent</td>
</tr>
<tr>
<td>Crises</td>
<td>Prevention planning</td>
</tr>
<tr>
<td>Deadline work</td>
<td>Trivial, some calls</td>
</tr>
<tr>
<td>III</td>
<td>IV</td>
</tr>
<tr>
<td>Interruption</td>
<td>Trivial, some calls</td>
</tr>
<tr>
<td>Some calls/meetings</td>
<td>Pleasant activities</td>
</tr>
</tbody>
</table>

Production / Production capacity

M - Society

大前研一, 2006

凸 – type ⇒ M-type

• Middle class disappear
  
  Few very rich
  Majority poor

• A large class of lower-middle people

  ➢ No goal
  Opportunity not equal to everyone

  ➢ Less motivated

• More contract-term/less tenured work

Solution:

Never expect a permanent job
Have a permanent ability to get a job
Global View

Running out of future resources for today’s growth

- Economic growth ⇒ Competition ⇒ Inflation
  - Competition ⇒ unbalanced distribution of energy
    Capitalization, job market, ... etc.
    Wealth (larger rich-poor gap in people and nations)

- Human nature ⇒ Competition ⇒ 泡沫

- Globalisation (flat world)
  winner takes all ⇒ competition↑

- Chinese culture --- similar value ⇒ competition↑

Impact to Academia

- Competition of universities - reputation
  (staff, student, fund,…)

- Competition of research - reputation
  (field, funds, students …)

- Competition of staff - promotion
  (funds, field, paper, students…)

- Competition of students - career
  (field, knowledge, Mark….)

- Competition of teaching – (OBLT - outcome based teaching & learning)
Challenge – Velocity $\uparrow \Rightarrow$ Quality $\downarrow$

- **Life** – greedy driven
  - Spending $\uparrow \Rightarrow$ Work/Money $\uparrow \Rightarrow$ time $\downarrow$

- **Business** – customer driven
  - Focus $\uparrow \Rightarrow$ Cost $\uparrow \Rightarrow$ Profit $\downarrow$

- **Academia** – paper/fund driven
  - Field (narrowly defined) $\downarrow \Rightarrow$ math $\uparrow \Rightarrow$ usefulness $\downarrow$
  - money $\uparrow \Rightarrow$ academics $\downarrow$

**Simplicity is beauty**

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**Blue Ocean Strategy**

W. Chan Kim & Renée Mauborgne, 2005

- No industry can grow forever;
- No company can grow forever;
- Only value creation can last forever;

<table>
<thead>
<tr>
<th></th>
<th>Old (red ocean)</th>
<th>New (blue ocean)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mkt/demand</td>
<td>Focus on existing</td>
<td>Create uncontested</td>
</tr>
<tr>
<td>Competition</td>
<td>Beat/fight</td>
<td>avoid</td>
</tr>
<tr>
<td>Profit/Cost</td>
<td>low</td>
<td>high</td>
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Example – Journal Publication

- **Phenomenon**
  Large amount of paper ⇒ Journals

- **Traditional approach (red)**
  Shorten review period ⇒ speed publishing

- **Prediction**
  M-society in Journals (few top, majority poor)
  Review request → junk mail

- **Solution?**
  Similar to Conference: more conferences each year
**Success – Innovation to make difference**

Win/Win approach to avoid over-competition ⇒ inflation↓

**Business**
- 3M (mkt, management, money)
- Innovation – redefine market

**Human**
- Mind development
- Innovation – find your life goal/unique plan

**University** – redefine its mission, unique identity

**Research** – redefine field and problem ⇒ objective;
innovatively integrate knowledge/tech

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**Example – Fashion changes in Research**

**Potential Research fields in Engineering**
- Semiconductor
- Tele-communication
- Information tech
- Bio-Naro
- New energy
- ............

**Redefine Control**
- Process-based
- Information based
- Multi-disciplines ⇒ hybrid/integrated
Core Competence

Research

Core tech

Applications

Not everything changes in the changing world

My Research into Future

Intelligent Process Modeling & Control

Control

FLC NN

Intelligent Control

Semiconductor processes

Spatial-temporal dynamic system

Design for control

3D FLC

TS-Fuzzy Cont DPS

3D kernel

Modeling

Learning

3D SVM

3D FLC

Bio/medical

Social system

CNN for learning

Decision making (high-level control)

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**Never Ending ....**

**Global Trend** ⇒
- challenge↑ → competition↑ → quality↓
- more uneven energy distribution → imbalance ↑

**Question:** If the trend keeps accelerating, can we still control it?
- **Win/Win** consideration
- **Reverse** the trend ⇒ slow down (spend↓ → earn ↓ → work ↓)

**Argument** exists in the **relative reality**:
- Nothing is wrong or right, only a question of choice!

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Thank you!