

CULTURAL FACTORS IN MODELING

A CASE STUDY: FUZZY LOGIC

Who will use the model?

- The operations research community knows how to construct mathematical models, but we often don't know whether they will be accepted and used.
 - Modeling is itself an activity characteristic of certain cultures. It should not be surprising that its application would be culturally based.
 - This is an attempt to begin to understand how modeling and culture relate, through a case study of fuzzy logic.

- Fuzzy logic (actually, fuzzy control) may provide some clues because cultural factors seem to have played an uncommonly obvious role in its application.
- It was initially developed in USA, Denmark, and U.K. Yet it was enthusiastically accepted in east Asia, particularly Japan, for some years while it was still viewed with suspicion in the West.

Origins of Fuzzy Logic/Control

- 1964 - Invented in USA by Lotfi Zadeh (Lotfi Aliaskerzadeh), native of Azerbaijan, also with Russian/Turkish/Iranian ancestry.
- 1973 - First commercial application (cement mixing), Denmark. Lauritz Peter Holmblad, Jens-Jorgen Ostergaard.
- 1973 - Application to steam engine control, U.K. Ebrahim Mamdani.
- 1980's - Enthusiastically accepted in Japan, later in Singapore and other parts of east Asia.

- 1980's - A large popular following in the West, but often sternly criticized or ridiculed by the scientific community. Relatively few applications in control (although a similar idea is used to process "confidence factors" in expert systems).
- 1990's - Neuro-fuzzy applications very popular in Asia.
- 1990's - Fuzzy control applications become widespread in the West.

The issue:

- Why was a mathematical technique that was developed in the West, where mathematical modeling is widely used, largely rejected by Western science while it was enthusiastically applied in Confucian cultures?

Some Proposed Explanations

- Western science has an ethic of difficulty or obscurantism, whereas fuzzy logic is simple.
 - It is hard to publish simple papers in Western journals.
 - One version of this explanation is Marxian: some mechanism is needed to control access to the scientific establishment, and a preference for difficult and arcane contributions meets this need.
 - *There is perhaps some truth to this view, but it is unclear why it would explain enthusiastic acceptance of fuzzy control in Asia.*

- Fuzzy logic is "feminine."
 - The Western scientific establishment is male dominated and prefers the masculine idea of categorical logic.
 - *By any reasonable measure, Japanese culture is the most masculine in the world (e.g., Hofstede's survey) and yet accepted fuzzy logic. (Interestingly, however, Danish culture is classified as "feminine.")*
 - *In any case, popular and ideological notions of masculine and feminine are vague and often do not accurately reflect their cultural meaning. Fuzzy logic could just as well be viewed as a masculine idea, because it tries to accommodate vagueness in a structured logical framework.*

- .Fuzzy logic harmonizes with Buddhism, which eschews sharp distinctions and categorical reasoning.
 - This explanation is often mentioned in the popular literature on fuzzy logic.
 - *Yet fuzzy logic is logic and is therefore already at odds with the anti-intellectual strain of Zen and Mahayana Buddhism. It recognizes vagueness but attempts to quantify it.*

Another Explanation

- Perhaps the key to understanding different attitudes toward fuzzy logic is to recall that they are different attitudes toward fuzzy control.
 - Western control theory is grounded in physics. It requires a detailed understanding of what Western science regards as the actual physical mechanism.
 - By contrast, fuzzy control is ad hoc. It consists of common sense rules in which membership functions have no necessary connection with physical law.

How Fuzzy Control Works

- A fuzzy controller consists of rules similar to:
 - If the pressure is too low but rising rapidly, then reduce the heat slightly.
 - If the pressure is high but constant, then reduce the heat substantially.
- [Diagram omitted.]

Western Emphasis on Technical Rationality

- Science-based manipulation of nature (i.e., technology) has long been a primary coping mechanism of Western culture.
 - Due to the West's Semitic roots, nature has been regarded as a secular realm (rather than pantheistically or animistically). Nature is "disenchanted."
 - This opened the way to application of classical Greek rationality to manipulation of nature, whence technology. Eventually nature became a controllable mechanism.

- Westerners reduce stress and uncertainty by controlling their environment.
 - They build transportation systems, power systems, social welfare systems, information systems.
 - In illness they turn to medical science for comfort.
 - Social problems are addressed with technology and macroeconomic models.
 - Beginning with the compass and gunpowder, technology is used to conquer nature and other peoples
 - to bring the natural and social world under control.
 - The basis of this control is the rational analysis of nature; i.e., understanding the natural mechanism.

- This is not to say that Western intellectual achievements are superior to those of other cultures.
 - In fact they borrow heavily from other cultures.
 - It is to say that technical rationality is a coping mechanism for everyday life to an extent not originally found elsewhere.
 - Because of this, Westerners can tolerate disintegrating families and individualism.
 - Other cultures adopt technology because they want it.
 - The West needs it.

Western and Eastern Reactions to Fuzzy Control

- Western science has a visceral reaction to fuzzy control as ad hoc and unprincipled.
 - Fuzzy control does not understand the natural mechanism.

- Asians have been impressed by the practicality of fuzzy control:
 - It is easy to understand.
 - There is no need to collect physical data (heat transfer coefficients, etc.) to describe boundary conditions.
 - If the controller doesn't work, simply add some more rules to fix it.
 - The controller is robust and degrades gracefully when data errors are introduced.
 - Many systems are impossible to model physically (e.g., cement mixing) but straightforward for fuzzy control.
 - Other systems have physical models that are too complex to implement.

- The same advantages operate in the West and eventually prevailed.
 - But Western acceptance was impeded by a negative reaction to the unprincipled nature of fuzzy control.
 - Asian acceptance was not.
 - This is the main difference.
- The West must maintain this kind of discipline, because it relies so fundamentally on rational analysis of nature. Confucian culture does not.

Other factors

- Fuzzy control rule bases can be compiled by group effort.
 - The Japanese tradition of group solidarity and consensus-building suited this task well.
- Sinic and to some extent Japanese cultures have a very practical bent.

General observations

- Operations research can be regarded as a quintessentially Western activity.
 - It applies rational analysis (in its most refined form, mathematics) to the management of nature and society.
 - The idea of optimization can be traced to the Western "Enlightenment" (e.g., Leibniz) and is rooted in classical Greek rationality.

- Yet in recent decades operations research has not used the traditional Western style of mathematical modeling.
 - A linear programming model normally does not describe a physical mechanism.
 - It is not modeling at all, in the sense employed in the natural sciences.

- There are similar developments in psychology and social sciences: psychometrics, econometrics.
 - In these fields no attempt is made to model the underlying natural process.
 - Neoclassical economics still tries to model an equilibration mechanism, but economists are more likely to concede a lack of verisimilitude than physicists.
- The "unprincipled" nature of OR modeling may make it amenable to multicultural use.

