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HIROTUGU AKAIKE, STATISTICAL SCIENTIST

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This talk was given after a banquet in honor of Hirotugu Akaike on May 28, 1992 at *The US/Japan Conference on The Frontiers of Statistical Modeling: An Informational Approach* [University of Tennessee, Knoxville TN May 24-29, 1992]. Contents are: 1. Change jokes; 2. Toasts; 3. History of statistics in real time: hammers and nails. 4. Akaike's career in statistical science; 5. The phases of Akaike's research; 6. Information statistical literacy.

1. Change jokes

A statistical tradition is that a statistical talk should begin with a joke. My current research interest is mainly in Statistical Change Analysis, and I am fond of "change" jokes of the form "How many statisticians does it take to change a light bulb?"

The answer appropriate for tonight may be: "Can we get back to you on that; our computers are working it out using Akaike's AIC criterion."

If you don't think that answer is funny, let's try another punch line: "To get a statistical job done (such as change a light bulb), it takes either two information statisticians, or four applied statisticians practicing Fisher/Neyman paradigms, or a six-pack of dogmatic Bayesians."

We can assert that almost surely a lone statistician cannot change a light bulb, because that would be too lonely (even if he or she is a Lone Star). It takes at least two statisticians to accept new paradigms in statistics and accept the alternative hypothesis that the light bulb does need change (the ever present null hypothesis of statistics is: no change observed).

Two traditional light bulb joke punchlines:

it takes zero Virginians to change a light bulb because they prefer to preserve it as a historical landmark;

it takes zero Jewish mothers to change a light bulb because they don't want to be any trouble (they say: please don't bother; we don't mind sitting in the dark).

Would it help us better understand the culture of our Japanese friends if they could tell us how many Japanese mothers are needed to change a light bulb?

Another interest of mine is Statistical Culture, the study of "what makes the discipline and profession of statistics run?". Do statisticians suffer from a lack of appreciation? Researchers in other fields often underestimate the value to them

of collaborating with a statistical scientist. Statisticians are often guilty of not understanding, and expressing appreciation of, their colleagues.

I conjecture that almost every statistician who does theoretical work that aspires to be applicable to the practice of statistics has experienced the reaction to one's latest proposals for statistical data analysis expressed in the following funny saying that conveys a message:

"It won't work.
If it works, it's not new.
If it's new, it's trivial."

2. Toasts

My attempts at humor are intended to convey a message: the criteria by which to measure the success of a theoretical statistician's research accomplishments are how well does his or her theories work in practice, how new are they, and how non-trivial are they.

These criteria prove objectively that our guest of honor Hirotugu Akaike is a great statistical scientist. He has introduced new methods (I propose below that methods may be called "hammers") which have enabled many other researchers to stand high and see far. His work has been influential because it has had an important component of interesting and very real practical applications (called "nails" below).

I would like to propose a toast to H. Bozdogan and the organizers of "The US/Japan Conference on the Frontiers of Statistical Modeling: an Informational Approach". They deserve our warm appreciation and praise for organizing a symposium in the United States for us to gather together from around the world, to greet and meet one another.

I would like to propose a toast to Hirotugu Akaike and to publicly express our thanks for his contributions to our lives by the theoretical and applied research which he has done and which he has stimulated.

I would like to propose a toast to the Institute of Statistical Mathematics which has provided Akaike with the support and freedom to have a distinguished career as a statistical scientist.

I would like to propose a toast to Statistical Time Series Analysis, and to the rare Statistics Departments which provide education in Time Series Analysis as practiced by Akaike's co-workers. Important contributions to the Japanese economy have been made by Akaike by training applied researchers to apply innovative Time Series Analysis methods which he has developed.

Each of us is here tonight because we have a special relationship to Akaike. Mine is that I have known Akaike since 1965 (that is 27 years ago) when we met in Japan at a U.S. Joint Seminar on Applications of Stochastic Processes to Engineering. I arranged for his first visit to the United States in 1966-67. Our special relationship is formed by the many good times we have had together, as well as by our shared research interests in time series analysis.

When in the early 1970's Akaike developed AIC as an order fitting criterion to determine the order of an autoregressive scheme, I was stimulated to develop an alternate criterion called CAT (criterion autoregressive transfer function) which

fortunately in practice usually yields similar answers. I should emphasize that AIC is a very general model selection method that applies to many statistical model building problems while CAT applies only to density estimation by autoregressive estimators.

My topic tonight is Akaike the statistical scientist. I would like to briefly mention Akaike the person. I regret to inform you, on the basis of more than 40 years of professional experience, that some of our colleagues are not nice people; there are productive statisticians of whom many say that "on a personal basis they can be tolerated only in small doses". The opposite extreme is true of Akaike. He is a wonderful and warm person whose company is very enjoyable and stimulating. His family consists of his wife Mitsuko, his three daughters Yumi, Chie, and Maki and their husbands, and his five grandchildren.

3. History of statistics in real time: hammers and nails

My task is to summarize the history of Akaike's research in statistical science in a way that enables each of us to comprehend the problems of the past and to help plan future directions. At the Conference of Texas Statisticians in February and the Interface between Computing Science and Statistics in March I gave after dinner talks about this process and have given it a name: "History of Statistics in Real Time: Hammers and Nails".

The title is motivated by the proverb: "To the statistician with a hammer, every problem is a nail". I propose that we respond: "The statistician needs a unified set of classical and modern hammers, so that almost every problem can be transformed to a nail. The statistician needs nails, so that the hammers can be fun (functional and fundamental)."

Analogous ideas are expressed by others. Akaike writes in his 1985 paper "Prediction and Entropy": *"The predictive point of view and the concept of entropy can produce a unifying view of statistics. For the development of statistics the main emphasis should be placed on the search for important practical problems."*

I propose that to understand the many influences that have contributed to the past history of modern statistics, and can guide the development of its future history, we should think of new developments as being of two types which we can call "hammers" and "nails". Nails are the applied phenomena and data that we research with the hammers, which are statistical methods (or "statistical datascopes" analogous to microscopes and telescopes).

To illustrate the distinction between hammers and nails I point out that when one proposes to a funding agency a symposium they demand a justification and ask "what's new to discuss?". The answer can be either "new theory and methods (new hammers)" or "new applications and data (new nails)."

As I study Akaike's career, I conclude that it has been so successful and is a role model for us because of the balance he has acheived between research on nails (applications) and research on hammers (methods). He has created fundamental statistical hammers that have become exoteric (consumer products for applied statisticians) rather than esoteric (just an intellectual game of theoretical statisticians).

The concepts of esoteric research yielding exoteric hammers (spinoffs) are intended to raise our consciousness about a research trend that often becomes apparent to senior scholars with many years experience: *the researchers in a field individually prosper doing research which adds to their reputation but the field as a whole is not prospering in the sense that it is not doing important things that have an impact outside of the field.* I believe that there is a remedy: researchers in the field should organize to do strategic planning, to act collectively to define the missions of the field and to ensure that things get done that (under the system of individual initiative) are alleged not to add to one's reputation.

Examples of how groups can aim to continuously improve the quality of their field: (1) stimulate expository review articles which call attention to methods which are the "best" hammers for applications and to important advice that were once published somewhere (and often are not given exoteric exposure because they are part of the folklore known to esoteric researchers); (2) raise consciousness about good taste in choice of research problems (which research problems are internally generated rather than externally generated, and which optimization criteria have scientific significance).

4. Akaike's career in statistical science

Akaike was born in Japan on November 5, 1927 (in Fujinomiya- shi, Shizuoka-ken). He completed the B.S. and D.S. degrees in mathematics at the University of Tokyo in 1952 and 1961. He has worked at the Institute of Statistical Mathematics since 1952.

[The Institute of Mathematical Statistics Bulletin issue of March/April 1992 has an article describing the current organization of the Institute (pp. 108-109). It has four departments (Fundamental Statistical Theory; Statistical Methodology; Prediction and Control; Interdisciplinary Statistics) and two centers (Statistical Data Analysis; Statistical Education and Information.)]

In discussing Akaike's career one should begin by noting that he has received many high honors. Within the Institute of Statistical Mathematics, he served as Professor and Head of Department of Prediction and Control, 1985-1986. Since 1986 he has served as Director General of the Institute of Statistical Mathematics during a period in which it has become a Ph.D. degree granting institution.

Akaike has been honored by invitations to be a visiting professor at many universities: Stanford, Tokyo, Nagoya, Harvard, Shizuoka, University of Manchester Institute of Science and Technology, Hawaii.

Within the statistical profession, Akaike has been honored by election to: Honorary member, Japan Statistical Society (he served as President, 1989-1990); Honorary Fellow, Royal Statistical Society; Fellow, American Statistical Association, Institute of Mathematical Statistics, Institute of Electrical and Electronic Engineers. He is a member of the International Statistical Institute (served as Vice President 1981-1983). Since 1976 he has been the Editor of the prestigious journal Annals of Institute of Statistical Mathematics (which I will refer to hereafter as AISM for Ann. Inst. Statist. Math.).

Akaike has received many honors within Japanese society. Akaike has been

awarded two important prizes: the 1972 Ishikawa Prize of Japan Union of Scientists and Engineers (for contributions to modeling, methods for analysis and control of dynamic systems especially work with Nakagawa on cement rotary kiln control), and the 1980 Okochi Prize with Hideo Nakamura (apply TIMSAC to electricity power plant control of steam boiler temperature using a high dimensional model with seven variables).

Akaike has made many important contributions to optimal control of complex engineering processes, using the computer program package TIMSAC (Time Series Analysis and Control) whose development began in 1971. TIMSAC has been applied in many areas of science, and its development is a major and continuing contribution. These research achievements, in the context of cement kiln control, are described in the book (published in 1972 in Japanese and in 1988 in English).

(1988) "Statistical Analysis and Control of Dynamic Systems", by Akaike and Toichiro Nakagawa, KTK: Tokyo and Kluwer: Dordrecht, Holland,

Akaike was awarded two especially significant honors in 1989: the Purple Ribbon Medal from Emperor of Japan; the Asahi Prize (for contributions to statistics, especially AIC).

5. The phases of Akaike's research

Akaike's research interests can be described in terms of seven phases:

I. 1952-1960 Launching period
II. 1960-1965 Power-spectrum and frequency response analysis
III. 1965-1969 Feedback system analysis
IV. 1969-1972 FPE
V. 1972-1974 AIC
VI. 1974-1977 TIMSAC
VII. 1977- Entropy modeling

I. The years 1952-1960 were Akaike's launching period. A noteworthy hammer (method) for estimation of the variance time curve is developed in the paper

(1959) "On the statistical control of a gap process" AISM 10,1-20; the related nail (application) is the first successful control of the silk reeling process by Akinori Shimazaki (of the Sericultural Experiment Station).

II. During 1960-1965 Akaike was concerned with power-spectrum analysis and frequency-response analysis. Significant hammers are:

(1962) "On the design of lag window for the estimation of spectra" AISM 14, 1-21.

(1962) "On the statistical estimation of frequency response function" AISM 14, 23-56 with Y. Yamanouchi.

The related nail is reported in the multi-authored

(1964) "Studies on the Statistical measurement of frequency response functions" AISM Supplement III, 102 pages which is an extensive report of a cooperative research project with engineers.

This collaboration lead to the 1965 U.S. Japan Joint Seminar on engineering

applications of stochastic processses, held in Japan. At this meeting Akaike and I met and became friends.

Another important application is reported in

(1962) Some estimation of vehicle suspension system's frequency response by cross-spectral method. Proceedings of the 12th Japan National Congress for Appl. Mech., 241-244, with Ichiro Kaneshige.

III. During the years 1965-1969 Akaike emphasized feedback system analysis. There were two basic papers in this period.

(1968) "On the use of a linear model for the identification of feedback systems." AISM 20, 425-439.

(1967) "Some problems in the application of the cross-spectral method", "Spectral Analysis of Time Series", B. Harris (editor), Wiley: New York, 81-107.

The 1967 paper was presented at an important symposium at the University of Wisconsin; it was one of several seminal presentations that were ignored at the time.

I believe that my paper at the symposium entitled "Time series analysis for models of signal plus white noise" also had more impact than was evident to the statisticians. I believe I can explain this neglect by a very interesting comment made to me after my talk by Henry Mann (a mathematician who had a distinguished mid-career in statistics): *"That's why I left statistics; instead of discussing what you did, they discussed why you should not have done it".*

IV. The FPE criterion for order determination, and control applications, was Akaike's research emphasis in the period 1969- 1972. Hammers were provided in

(1969) "Fitting autoregressive models for prediction" AISM 21, 243-247, the first FPE paper.

(1970) "Statistical predictor identification" AISM 22, 203- 217, provides detailed analysis of FPE.

The nail (application) was presented in

(1972) "Statistical approach to computer control of cement rotary kilns" (with T. Otomo and T. Nakagawa) Automatica 8, 35-48 This application was related to the Ishikawa prize.

V. One of the major statistical hammers of our time was Akaike's development of AIC in the years 1972-1974. There are two highly cited papers:

(1973) "Information theory and an extension of the maximum likelihood principle" 2nd International Symposium on Information Theory, B. N. Petrov and F. Csaki, eds., Akademiai Kiado, Budapest, 267-281. [Reprinted with an introduction by Jan DeLeeuw, in Breakthroughs in Statistics Volume I, edited by S. Kotz and N. L. Johnson, Springer Verlag: New York, 1992].

(1974) "A new look at the statistical model identification" IEEE Trans. Automat. Conrol, AC-19 716-723. This paper has been denoted by the Institute for Scientific Information as one of the most frequently cited papers in the area of engineering, technology, and applied sciences.

In the IEEE special volume in which Akaike's (1974) paper was published the following paper (pages 723-730) was by me, entitled "On some recent advances in time series modeling". It introduced CAT which was extended in 1977 in my paper "Multiple time series: Determining the order of approximating autoregressive schemes", *Multivariate Analysis IV*, edited by P.R. Krishnaiah, Academic Press: New York, pp. 283-295.

VI. State space modeling to identify parsimonious models for mutivariate time series was Akaike's emphasis during 1974-1977; this hammer was reported in

(1974) "Markovian representation of stochastic processes and its application to the analysis of autoregressive moving average processes" AISM 26, 363-387

An almost automatic procedure for ARMA model fitting is provided in

(1975) "TIMSAC-74, a time series analysis and control program package" with E. Arahata and T. Ozaki, Computer Science Monographs No. 5, The Institute of Statistical Mathematics .

VII. Since 1977 Akaike has published more than 50 papers on entropic point of view, Bayesian modeling, and related philosophical considerations. The more important theoretical papers include:

(1977) "On entropy maximization principle" Applications of Statistics, ed. P. R. Krishnaiah, North Holland: Amsterdam, 27-41

(1978) "A new look at the Bayes procedure, Biometrika 65, 53-59

(1978) "A Bayesian analysis of the minimum AIC procedure" AISM 30, 9-14, studies AIC versus BIC, Schwarz criterion.

(1980) "Seasonal adjustment by a Bayesian modeling" Journal of Time Series Analysis 1, 1-13

(1980) "Likelihood and the Bayes procedure", Bayesian Statistics, University Press: Valencia (Spain), 143-166. First introduction of BATSEA procedure.

An application (nail) related to the Okochi prize is

(1981) "Statistical Identification for optimal control of supercritical thermal power plants." with H. Nakamura, Automatica, 17, 143-155

A geophysical application is

(1983) "A Bayesian approach to the analysis of earth tides" with M. Ishiguro, H. Ooe, S. Nakai. Proceedings of the Ninth International Symposium on Earth Tides, ed. J. T. Kuo, 283-292

6. Information statistical literacy

What statisticians do is even analyzed in comic strips. A comic strip about career advice had the following dialogue.

Client to counselor: I'd like to become a statistician. What are my chances?

Counselor to client: If you don't know, you've made the wrong choice.

Our meeting here this week might be summarized by the following analogous humor.

One statistician to another: I'd like to become an information statistician. What are my chances?

Answer: If you don't know, you should consult a statistician who attended the May 1992 Conference on the Informational approach to Statistical Modeling.

Perhaps the best introduction to Akaike's philosophy is his paper

(1985) "Prediction and entropy", A Celebration of Statistics, A. C. Atkinson and S. E. Fienberg, eds. Springer Verlag: New York,1-24.

Its key words summarize the minimum statistical literacy requirements of a modern statistician who wants to benefit from Akaike's work:

AIC,
Bayes procedure,
Entropy,
entropy maximization principle,
information,
likelihood,
model selection,
predictive distribution.
development of statistics through important practical problems.

I hope this meeting has stimulated your interest in discussing with your colleagues the question of how to improve the quality of the art of statistical science by learning and teaching more about information statistics. An introductory textbook is

(1983) Akaike Information Criterion Statistics, Y. Sakamoto, M. Ishiguro, and G. Kitagawa, D. Reidel: Boston.

It is good that we meet together, to enjoy fond memories of meetings past, and to stimulate warm wishes for meetings future. It is good to review Akaike's career, to draw inspiration about how each of us might have an impact on the work of others.