Time Series Analysis Group of COE (Center of Excellence)

Activity Report

The Institute of Statistical Mathematics, Tokyo, Japan

Contents

1. Organization of COE-TSA group

1.1. COE project

The COE stands for "Center of Excellence". Under a leadership of Director-General of the Institute of Statistical Mathematics (ISM), Dr. R.Shimizu, the COE consists of the five groups:

- Information and Statistics Group (Coordinator: Matsunawa)
- Molecular Evolution Group (Hasegawa)
- Optimization and Control Group (Mizuno)
- Time Series Analysis (**TSA**) Group (Higuchi)
- Survey Group[1] (Yanagimoto)

We simply denote the COE Time Series Analysis Group by **COE-TSA** hereafter.

The concept behind starting the COE at the ISM is aimed at initiating the project group for a relatively long-term period, actually, five years of 1995/April—2000/March. Each group consists mainly of the staffs of the ISM, but is allowed to involve the graduate students, the postdocs, and visiting researchers at the ISM. Therefore it turns out that the organization of the COE is not related to one of the ISM (the organization of the ISM can be referred to `http://www.ism.ac.jp/english/org.html`).

1.2. COE-TSA group

There are four projects conducted by the members of COE-TSA: (A) Development of softwares for time series analysis, (B) Statistical modeling of financial time series, (C) Seasonal adjustment methods, and (D) Analysis of the space-time series data and Bayesian approach. The proposal to carry out these four projects has been made in the first year of the five years COE project. A member of the COE-TSA makes his/her contribution to the projects which he/she decided to join. We summarize the aims and scopes for each project below.

- **Subgroup–A: Development of softwares for time series analysis**
  (Subgroup Leader: *Tamura*)
  The TIMSAC has evolved in accordance with change in environment surrounding the computers. In particular, a strong demand of users who are eager to perform a statistical analysis with comfortableness has driven us to modify the design of softwares. It results in a fact that we developed the TIMSAC for MS-Windows, TIMSAC for X-Windows, and then TIMSAC for SAS/IML in response to the user's request.

  Recently, many useful softwares after TIMSAC-84 has been developed at the ISM. For examples, the non-Gaussian and/or non-linear models are applied to specific problems through the collaborations carried out by the members who developed the softwares. We believe that if we can modify these softwares so as to perform a statistical analysis under the GUI (Graphical User Interface), the benefit of applying recent time series models would be opened to the public. We hope an accomplishment of this project will expand the applicable domain (field) to social sciences such as economics and business beyond

[1] This English translation of the proposal for this group written in Japanese is not authorized by the coordinator.

natural sciences. In addition to implementation of these recent models, we are aiming at developing a new method of the time series analysis with help of an information criterion which guides us to perform a statistical analysis objectively.

- **Subgroup–B: Statistical modeling of financial time series**
  (Subgroup Leader: *Kawasaki*)
  The ISM cooperative research projects have been so far concentrated on natural sciences and engineering field. On the other hand, much attentions have been paid for financial time series analysis especially for recent years. This can be also seen in the fact that the statistical consultation related to financial statistics have been increased in our institute, and that the students who want to major in financial time series analysis constantly enter the PhD course of our university, the Graduate School of Advanced Studies.

  The aim of this project is firstly to organize the team, to show this is the possibly fruitful application field in the near future. Secondly, to develop new methods and modelings, making the advantage of our modeling resources and numerical experiences; structural time series modeling, non-Gaussian filter/smoother, non-linear dynamical system and the local linearization, etc.

  Specifically, the local linearization method is useful to estimate continuous time interest rate models. Non-Gaussian filter/smoother and Monte Carlo filter/smoother can be applied in the estimation of various volatility models. Also expected are the cooperative research works with financial institutions, and supervising the governmental committee on risk management.

- **Subgroup–C: Seasonal adjustment methods**
  (Subgroup Leader: *Kitagawa*)
  A seasonal adjustment method is important for the analysis of economic time series. It can be said that a seasonal adjustment is a typical problem in time series analysis because this problem offers a motivation for developing new estimating methods and give a good opportunity to practice the time series analysis.

  In our institute, the problem of seasonal adjustment was one of the motivation that we started to use Bayes model and the state space model which eventually led to the development of new time series modeling methods. In this research, our targets are to improve these methods and to develop new methods, and to establish the standard method for this seasonal adjustment.

- **Subgroup–D: Analysis of the space-time series data and Bayesian approach**
  (Subgroup Leader: *Ogata*)
  The ISM is proud of having much experiences in exploiting the state space model for an analysis of the nonstationary time series within a framework of the Bayesian approach. In addition, there are researchers in the ISM who applied the Bayes model with large number of stochastic variables to an analysis of the spatial pattern, e.g., the image restoration, modeling of a spatial point process. Some members paid considerable attentions to an inverse problem along the Bayesian modeling. There are many successful applications of these Bayesian modeling to real problems. By combining acquired knowledge, we are attempting to extend a framework of these various modeling towards an analysis for a space-time series data set.

  The analysis of the space-time series are expected to become very important, because unexpected development of the devices for measurements provides us with huge amount of the space-time series data. This tendency is enhanced with the development of a system

to provide us with various services as to data managements through the Internet. The COE-TSA group has to accommodate itself to such change in data format, and select this theme as one of the targets to be solved. The initiation of this project will bring about the new models and turn out to require a new computational technique to deal with them. Our targets are set to develop a new method for an analysis of the space-time series and to promote further strong collaboration with researchers in various fields by means of applying it to the real problems.

1.3 List of Members of the Time Series Analysis Group at ISM

(in Alphabetically Ordered)

Name (Subgroup)
E-mail
URL

Emiko ARAHATA (A,D)
arahata@ism.ac.jp
`http://www.ism.ac.jp/~arahata`

Tomoyuki HIGUCHI (C,D) ..... *Coordinator of COE-TSA*
higuchi@ism.ac.jp
`http://www.ism.ac.jp/~higuchi`

Yukio IBA (D)
iba@ism.ac.jp
`http://www.ism.ac.jp/~iba`

Makio ISHIGURO (A,C,D)
ishiguro@ism.ac.jp
`http://www.ism.ac.jp/~ishiguro`

Nobuhisa KASHIWAGI (D)
kashiwagi@ism.ac.jp

Yoshinori KAWASAKI (B,C) ..... *Leader of Subgroup–B*
kawasaki@ism.ac.jp

Genshiro KITAGAWA (A,C,D) ..... *Leader of Subgroup–C*
kitagawa@ism.ac.jp
`http://www.ism.ac.jp/~kitagawa`

Junji NAKANO (A)
nakano@ism.ac.jp

Yosihiko OGATA (D) ..... *Leader of Subgroup–D*
ogata@ism.ac.jp
`http://www.ism.ac.jp/~ogata`

Tohru OZAKI (B,C)
ozaki@ism.ac.jp
`http://www.ism.ac.jp/~ozaki`

Seisho SATO (C)
sato@ism.ac.jp
`http://www.ism.ac.jp/~sato`

Makoto TAIJI (A)
taiji@ism.ac.jp

Yumi TAKIZAWA (D)
takizawa@ism.ac.jp
`http://www.ism.ac.jp/~takizawa`

Yoshiyasu TAMURA (A,B) ..... *Leader of Subgroup–A*
tamura@ism.ac.jp
`http://www.ism.ac.jp/~tamura`

Kunio TANABE (D)
tanabe@ism.ac.jp

Sumiyo UEDA (A)
ueda@ism.ac.jp

Satoshi YAMASHITA (B)
yamasita@ism.ac.jp
`http://www.ism.ac.jp/~yamasita`

2. Activities of Members (in Alphabetically Ordered)

This section describes the activity of members who belong to the COE-TSA group. Each member was required to give information on several items:

- **Name**
- —**Keywords**: Keywords
- —**Research**: Description of Past Research (Research interest and activities)
- —**Plan**: Future Plan and Scope
- —**References**: Main Papers (References) selected by each member.

Emiko ARAHATA

— Keywords

State space representation, Kalman filter, Smoother, the computation Maximum Likelihood and AIC

— Research

We developed the package for drawing the graphs with X-Y plotter in Comparative Study of the X-11 and BAYSEA procedure of Seasonal Adjustment, in Applied Time Series Analysis of Economic Data(Zellner, A.) U.S. Department of Commerce, Bureau of the Census, 17-53 by Akaike, H. and Ishiguro,M. (l983). Recently I study a time series analysis with missing observations and algorithm, and am involved in developing it's software (Fortran program) with G. Kitagawa.

— References

A Bayesian Spline regression (in Japanese), Proceeding of the Institute of Statistical Mathematics, vol.30 no.1 29-36, (with M. Ishiguro) 1982

On the application of the McAuley method to the solution of Characteristic equations arising in time Series analysis (in Japanese), Proceedings of the Institute of Statistical mathematics, vol.34, No.2, 233-239,l986

Analysis of water flow of Kusu river in an interconnected multi-reservoir power system (in Japanese), Proceedings of the Institute of Statistical Mathematics, Vol.38, No.1, 19-30 (with K. Tanabe et al.) l990

Tomoyuki HIGUCHI

— Keywords

Bayesian model, Bootstrap method, Fractal analysis, Generalized State Space Model, Genetic Algorithm, Spacecraft, Underground water

— Research

- **Fractal analysis of a time series analysis**
  I proposed the method for characterizing a randomness of the time series in terms of the fractal dimension (Higuchi, 1988, 1990). This method has been widely adopted in many fields as one of the tools for measuring the randomness of the time series which shows a complicated behavior in time domain. We applied this technique to the magnetic filed turbulence observed by the spacecrafts with highly fluctuations, and suggested a possible geophysical mechanism based on the results to support one of models in controversial understanding of the fundamental phenomena in the space physics.

- **Separation of spin synchronized signals**
  A regular self-rotational motion (spin) around the spin axis of their body is given to many of satellites for the stabilization of attitude. The spin is likely to bring about cyclical noise to observations. It turns out that information is buried in false information. I proposed several models to deal with a separation of the spin synchronized noise, which were realized by implementing them to the state space model (these models are summarized in Higuchi (1999a)). I developed the softwares and applied them to many observations obtained by the international satellites (Higuchi *et al.*, 1988, Kita *et al.*, 1989, Higuchi 1991, Higuchi *et al.*, 1994, and so on)

- **Genetic algorithm filter**
  The Monte Carlo Filter (MCF) has been introduced to overcome a numerical problem in dealing with the generalized state space model with relatively high state dimensions. I pointed out that there exists a close relationship between the MCF and the genetic algorithm (GA) that is one of famous stochastic optimization techniques. I proposed the filter that replaces the step of prediction in MCF by the mutation and crossover operators in the GA (Genetic Algorithm Filter (GAF)). The proposed method is applied to the seasonal adjustment in order to illustrate how the system parameters (like hyperparameters in the Bayesian framework) evolves and shows a self-organized convergence according the GA operators.

- **Seasonal adjustment for small count time series**
  The quasi–periodic oscillation models for an analysis of small count time series are considered within a framework of a generalized state space model (GSSM). In particular, a special focus is laid on the analysis of a seasonal count data. The Monte Carlo filter (MCF) is fully employed in this study to handle a generalized state space model with higher state dimensions. As an example, we study seasonal count data set previously analyzed polio incidence time series, the monthly number of the drivers killed in the road accidents, and monthly numbers of the sun's spotless days. In addition, we demonstrate an application of the model proposed to an yearly occurrence of intense hurricanes with a quasi periodic component associated with a solar cycle activity (Higuchi, 1999b).

- **Application of Continuous stochastic differential model**
  We proposed the method to detect changes in the underground water radon concentration

related to an earthquake. We express a physical mechanism in a radon-detection chamber by using the linear stochastic differential equations. The temperature effect that strongly affects the solubility of radon in water can be satisfactorily removed by our procedure and so that we are able to estimate the original radon contamination in the groundwater before it was introduced into the radon-detection chamber. The proposed method can detect anomalous changes associated with earthquakes easily and allows us to investigate time-variation patterns of changes in groundwater radon (Higuchi *et al.*, 1995).

— Plan

- **Generalized State Space Model (GSSM)**
  - *Time-Varying Frequency Wave*:
    My interest has been paid to an estimation of the time-varying frequency of wavy behaviors in a presence of "heavy" colored noise. I modeled it within a framework in the GSSM and tried to apply the MCF for realization of the estimation of the state, but found no satisfactory result can been obtained. I think most of difficulty in the state estimation stems from a bilinear form between the state elements in this modeling. I would like to make a progress in solving a numerical problem as well as in developing a new model for such particular problem.
  - *Self–Organizing System*:
    I implemented two operations of the GA into the prediction process of the MCF. These operations show more effective performance for detecting a rapid change in the system under consideration if we can adopt a way of the parameterization suitable for the operations. I try to take an advantage of this benefit of the GA and to accommodate this requirement to the GSSM.
- **Discovery Science (Data Mining)**
  Recently, the word of Knowledge Discovery in Database (KDD) which has frequently used in the AI community, becomes popular in statistical science. The data mining is, specifically, a general term of numerical and computational techniques to realize the KDD. My study in handling a huge data set such as the satellite data can be regarded as a statistical approach to the KDD in terms of the KDD terminology. I have already started two projects concerning to the KDD.
  - *Space weather forecasting*:
    Characteristics of large-scale field-aligned currents (LSFAC) observed above the Earth's ionosphere are highly variable, and we have been depending on visual examination to identify LSFAC systems. We have started to developed to automatically identify the spatial structure of LSFAC from satellite magnetic field measurements. Understanding how a FAC system depends on solar wind conditions not only provides information on the generation mechanism of a FAC but also is important in predicting magnetospheric and ionospheric activities from the solar wind observation. Development of such a prediction system, space weather forecasting, is becoming an important element of space science, as space environment, which is influential to the operation of satellites, and more relevant to human activities. The developed automatic procedure to identify the structure of FAC systems can be used to conduct such scientific and environmental studies.

– *GPS meteorology*:
The GPS (Global Positioning System) is one of most interesting and important data set which allows us to investigate a global change in environment precisely. In particular, recent interest is laid on the GPS meteorology because a proper processing of the GPS data set enables us to estimate a high frequent spatial pattern of the PWV (precipitable water vapor) which plays important role in forecasting a weather map. We begin with an analysis of the GPS array data provided by the Geographical Survey Institute of Japan (GSI) in an attempt to understand how the PWV appears in the GPS array data. This project is a cooperative research with the GSI. While an importance of this project from a viewpoint of the geophysics is obvious, we hope it draws much interest from the statisticians.

- **Library of Orthonormal Bases**
I have learned the local discrete sine and cosine (LDST/LDCT) bases Coifman and Meyer that is one of the Wavelets bases. This approach can be very useful in nonstationary time series analysis, because the data is first partitioned into disjoint intervals smoothly and construct orthonormal bases on each interval. I think a flexible partition of the time axis draws my interest in application of the LDST/LDCT representation to the problem mentioned above.

  The concept of the library of orthonormal bases is that we try to find the most suitable basis for a particular signal from the collection of bases, which we call Library of Orthonormal Bases. Usually, a selection of bases is carried out according to the MDL principle. We consider this problem in terms of AIC.

— References

Higuchi, T. (1988). Approach to an irregular time series on the basis of the fractal theory, Physica D, Vol. 31, pp 277-283.

Higuchi, T., Kita, K. and Ogawa, T. (1988). Bayesian statistical inference to remove periodic noises in the optical observation aboard a spacecraft, Applied Optics, Vol. 27, No. 21, pp 4514–4519.

Kita, K., Higuchi, T., and Ogawa, T. (1989). Bayesian statistical inference of airglow profiles from rocket observational data: comparison with conventional methods, Planetary Space Science, Vol. 37, No. 11, pp 1327-1331.

Higuchi, T. (1990). Relationship between the fractal dimension and the power law index for a time series: a numerical investigation, Physica D, Vol. 46, pp 254-264.

Higuchi, T. (1991). Frequency domain characteristics of linear operator to decompose a time series into the multi-components, Annals of the Institute of Statistical Mathematics, Vol. 43, No. 3, pp 469-492.

Higuchi, T. (1991). Method to subtract an effect of the geocorona EUV radiation from the low energy particle (LEP) data by the Akebono (EXOS-D) satellite, Journal of Geomagnetism and Geoelectricity, Vol. 43, pp 957-978.

Higuchi, T., G. K. Crawford, R. J. Strangeway, and C. T. Russell (1994). Separation of spin synchronized signals, Annals of the Institute of Statistical Mathematics, Vol. 46, No. 3, pp 405-428.

Kawano. H., and T. Higuchi (1995). The Bootstrap Method in Space Physics: Error Estimation for the Minimum Variance Analysis, Geophysical Research Letter, Vol. 22, No. 3, pp 307-310.

Higuchi, T., Igarashi, G., Tohjima, Y. and Wakita, H. (1995). Time series analysis of groundwater radon using stochastic differential equations, Journal of Physics of the Earth, Vol. 43, No. 2, pp 117-130.

Higuchi, T. (1996). Genetic Algorithm and Monte Carlo Filter (in Japanese with English Abstract), Proceedings of the Institute of Statistical Mathematics, Vol. 44, No. 1, 19-30.

Higuchi, T. (1997). Monte Carlo filter using the Genetic algorithm operators, Journal of Statistical Computation and Simulation, Vol. 59, No. 1, 1-23.

Higuchi, T. (1997). A seasonal adjustment designed to deal with the time series observed in the natural phenomena (in Japanese with English Abstract), Proceedings of the Institute of Statistical Mathematics, Vol. 45, No. 2, 319-328.

Kitagawa, G. and Higuchi, T.(1998). Automatic Transaction of Signal via Statistical Modeling, The proceedings of The First International Conference on Discovery Science, Springer-Verlag Lecture Notes in Artificial Intelligence Series, 375-386.

Higuchi, T. (1999a). Processing of Time Series Data Obtained by Satellites, The Practice of Time Series Analysis (eds. H. Akaike and G. Kitagawa), pp 313-326, Springer-Verlag New York.

Higuchi, T. (1999b). Applications of Quasi-Periodic Oscillation Models to Seasonal Small Count Time Series, Computational Statistics and Data Analysis, (in press)

Yukio IBA

— Keywords

Markov Chain Monte Carlo, Extended Ensemble, Multicanonical, Metropolis-Coupled Chain, Multi-Self-Overlap Ensemble, Multi-System-Size Ensemble, Mean Field Approximation, Bayes Model, Variable Selection

— Research

In statistical physics, we should treat probability distributions with large number of stochastic variables. For this purpose, a variety of computational techniques are developed and shown to be useful in the study of qualitative and quantitative properties of materials and elementary particles. Recently, these techniques are applied to the problems in statistics. A remarkable example is Markov chain Monte Carlo algorithms (MCMC), which enable the treatment of large scale non-Gaussian models in Bayesian statistics. Other techniques for the approximation of the averages over highly multivariate distributions, say Mean Field Approximations, are also useful in data analysis with complicated statistical models. In this project, we developed new algorithms of MCMC and show that they are successfully applied to hard problems in computer science. We also studied an application of mean field approximation in statistics.

Our study of MCMC in the project is focused on the algorithms with extended ensembles. In these methods, we simulate an ensemble that consists of an artificial mixture or extension of the

target probability distributions. Then, fast mixing of the Markov chain is attained in a part of the components, say, high temperature components of a mixture. The most popular families of the algorithms with extended ensembles are known as multicanonical algorithm, simulated tempering algorithm, and Metropolis-coupled chain algorithm (exchange Monte Carlo algorithm). A mixture of the distributions of different temperatures, or, different hyperparameters is used in the majority of the studies with extended ensembles. We can design, however, different types of mixtures, often specialized to a model.

In the present study, we developed two algorithms with extended ensembles. First, we designed multi-self-overlap ensemble for a self-avoiding polymer on a lattice, which contains interacting walks with different degree of self-overlaps and different temperatures [1]. The penalty to the self-overlap is tuned in preliminary runs to make the ensemble contain an adequate portion of self-avoiding configurations. We can obtain correct averages if configurations with self-overlaps are discarded from the calculation of statistics. An algorithm with this ensemble is applied to lattice protein models and shown to be a very powerful tool both for the sampling of configurations [1,*] and solve the optimization problem of searching the lowest energy configuration of a polymer [*]. This algorithm will be useful to solve the protein design problem, which has some common features with maximum likelihood inference and learning in neural networks [2]. Second, we have studied algorithm with another ensemble, multi-system-size ensemble [3]. This ensemble consists of components each of which corresponds to the system of different sizes. The algorithm is successfully applied to an Ising spin glass model, which contains a number of binary discrete variables.

We also studied a mean field approximation in the variable selection for multiple regression [4]. We consider a Bayesian treatment of the problem and represent a submodel with a discrete indices $\{\sigma_i\}$, where the ith explanatory variable is included in the submodel if $\sigma_i = 1$, else 0. Then we can apply mean field approximation for calculating the marginals over the posterior of $\{\sigma_i\}$. In the literature, such calculations are performed by exact enumeration or MCMC, but the present method provide an alternative, which is much computationally economical.

— Plan

We are planning to study applications of extended ensembles in statistical inference. An interesting example is provided by image restoration with Markov field priors. Another interesting project is the construction of a coherent variable selection procedure with a combination of the mean field variable selection procedure and a bootstrap based information criterion (EIC) which has been developed by a group of Institute of Statistical Mathematics.

— References

[1]Y.Iba, G.Chikenji and M.Kikuchi (1998). Simulation of Lattice Polymers with Multi-Self-Overlap Ensemble, J.Phys.Soc.Japan, Vol.67, pp.3327-3330.

[2]Y.Iba (1998). K.Tokita and M.Kikuchi, Design Equation: A Novel Approach to Heteropolymer Design, J.Phys.Soc.Japan, Vol.67, pp.3985-3990.
[3]Y.Iba (1999). Simulation of Spin Glass with a Multi-System-Size Ensemble, J.Phys.Soc.Japan, Vol.68, in press.

[4]Y.Iba (1998). Mean Field Approximation in Bayesian Variable Selection Proceedings of ICONIP'98 Vol.1 530-533, Eds. S.Usui and T.Omori, Ohmsha, Tokyo and IOS Press, Burke VA USA

[*]G.Chikenji, M.Kikuchi and Y.Iba, Multi-Self-Overlap Ensemble for Protein Folding Thermodynamics, in preparation.

Makio ISHIGURO

— Keywords

multivariate time series, Information Criterion, causality, system analysis, physical interpretation

— Research

- **Bayesian Seasonal Adjustment model/BAYSEA**
  We developed Bayesian Model of time series with seasonal variation and trend/cycle. This model allows easy modifications such as, for example, attachment of Week Day-Effect term. Goodness of fit can be judged with easily obtained ABIC value. With ABIC, additive model and multiplicative model are comparable.

- **Bayesian tidal Analysis model/BATAP-G**
  Tidal Analysis is an important way of getting information about the deep interior of the Earth. Observed record are the response of the Earth to the Luna-Solar force plus response to the local atmosphere pressure movement plus drift from unknown cause. The developed model consists of tidal term, air pressure term plus drift term. Using the fact that frequency distributes of Luna-Solar input force is precisely known, frequency domain modeling is employed for the tidal term. Goodness of fit is judged with ABIC. There are two types of user of this model, the first group is of those who are interested in tidal term and think drift term as noise the other group is of those who are interested in estimating drift and regard tidal term as noise.

- **MARTS model**
  This is a multivariate AR model with Trend and Seasonal component. It is essentially a multivariate version of Kitagawa's DECOMP. This model is free from the difficulty in the goodness evaluation of the seasonal-adjustment/detrend-of-each-series-first-then-multivariate-analysis- of-whole-series approach to economic multivariate time series analysis.

- **Teleological Model**
  There are two opposing (or complementary) way of explaining dynamic behavior of systems in varying environment. One is to explain the behavior as responses to stimuli. The other is to explain the behavior as something for purpose. We will call these ways of explanation by causal explanation and teleological explanation, respectively. Proposed a model is to give a teleological explanation for behavior of linear system. The model is derived from essentially a causally explaining multi-variate AR model, by reparametrizing coefficients matrices as a function of parameters which have teleological interpretation.

— Plan

non-linear time series, brain system analysis, economy system analysis

— References

http://www.ism.ac.jp/~ishiguro/works.MODEL.E.html

Multivariate AR model

Ishiguro, M. (1998). Teleological Model, Proceedings of the Institute of Statistical Mathematics, Vol.46, No.2, in press. (in Japanese)

Kato, H. & Ishiguro, M. (1997). Dynamical Analysis for Economic System by Multivariate Time Series Model, Proceedings of the Institute of Statistical Mathematics, Vol.45, No.2, pp.301-318. (in Japanese)

Ishiguro, M. and Ooya, T (1995). Analysis of Driver-Bicycle System with ARdock, in Practice of Time series Analysis II(Akaike,H. & Kitagawa, G.), pp.19-39, Asakura Publishing Company, Tokyo. (in Japanese)

Ishiguro, M. (1994). System Analysis and Seasonal Adjustment through Model Fitting, in The First US/Japan Conference on the Frontiers of Statistical Modeling: An Informational Approach(Bozdogan, H.), PP.79-91, Kluwer, Netherlands.

Ishiguro, M. and Ogawa, T. (1991). Simulation of Infant Brain malfunction by MAR and its growth, in Proceedings of the 6th Biological and Physiological Engineering(Soc. Instrument and Control Engineers), pp.177-180. (in Japanese)

Ishiguro, M. (1991). Information Criterion, Bootstrap Technique and Time Series Analysis, ISM research program report, No.31 1991.9, pp.155-159. (in Japanese)

Ishiguro, M. (1989). System Analysis with Multivariate AR model, Operations Research, Vol.34, No.10, pp.547-554. (in Japanese)

BAYSEA

Akaike, H. and Ishiguro, M. (1985). BAYSEA, in TIMSAC-84, Computer Science Monographs(Akaike, H.), Vol.22, pp.1-55, The Institute of Statistical Mathematics.

Ishiguro, M. (1984). On the Use of Multiparameter Models in Statistical Measurement Techniques, Doctoral Dissertation, Univ. of Tokyo.

Akaike, H. and Ishiguro, M (1983). Comparative Study of the X-11 and BAYSEA Procedure of Seasonal Adjustment, in Applied Time Series Analysis of Economic Data(Zellner, A.), pp.17-53, U.S.Department of Commerce, Bureau of the Census.

Ishiguro, M. and Akaike, H. (1981). A Bayesian Approach to the Trading-day Adjustment of Monthly Data, in Time series Analysis(Anderson, O.D. and Perryman, M.R.), pp.213-226, North-Holland.

BAYTAP

Tamura, Y., Ooe, M., Sato, T. and Ishiguro, M (1991). A Procedure for Tidal Analysis with a Bayesian Information Criterion, Geophysical Journal International, Vol.104, pp.507-516.

Ishiguro, M and Y.Tamura (1985). BAYTAP-G, in TIMSAC-84, Computer Science Monographs(Akaike, H.), Vol.22, pp.56-117, The Institute of Statistical Mathematics.

Ishiguro, M., Akaike, H., Ooe, M. and Nakai, S. (1983). A Bayesian Approach to the Analysis of Earth Tides, in in Proc. 9-th Int. Symp. on Earth Tides(J.T.Kuo), pp.283-292, Eschweizerbart, New York.

MARTS

Kato, H., Naniwa, S. and Ishiguro, M. (1996). A Bayesian Multivariate Nonstationary Time Series Model for Estimating Mutual Relationships among Variables, Journal of Econometrics, Vol.75, pp.147-161.

Ishiguro, M. and Kato, H (1995). Economic System Analysis, Mathematical Sciences, No.389, pp.50-57. (in Japanese)

Bayesian

Yafune, A., Ishiguro, M. and Kitagawa, G. (1996). Kullback-Leibler Information Approach to the Optimum Measurement Point for Bayesian Estimation, Communications in Statistics, Vol.25, Issue 3, pp.519-536.

Yafune, A., Matsubara, T. and Ishiguro, M. (1993). Bayesian Analysis of Lymphatic Spreading Patterns in Cancer of the Thoracic Esophagus, Annals of the Institute of Statistical Mathematics, Vol.45, No.3, pp.401-418.

Yafune, A. and Ishiguro, M. (1992). A smooth estimation of the prior distribution in a Bayesian model for clinical data analysis –An use of EIC(an Extended Information Criterion)–, Research Memorandum No. 456, The Institute of Statistical Mathematics, Tokyo.

Gaussian

Yafune, A. & Ishiguro, M. (1989). Fitting Multidimensional Normal Distribution Model to Clinical Repeated Measurements, in Proceedings of the Annual Meeting of Japan Statistical Society(Japan Statistical Society), pp.129-131, Japan Statistical Society. (in Japanese)

Spatiotemporal

Ishiguro, M. (1995). A Spatiotemporal Model of Atmospheric Fluctuation II, Research Memorandum No. 548, The Institute of Statistical Mathematics, Tokyo. (in Japanese)

Nobuhisa KASHIWAGI

— Keywords

Space Time Smoothing, Space Time Seasonal Adjustment, Space Time Inverse Analysis

— Research

- **On water quality in Tokyo Bay:**

  In Tokyo Bay, water quality has been measured by the related local governments every month at scores of monitoring points for the administrative purpose. We are carrying out the plan of collecting and screening the measured values reported for the past two decades to reuse them for scientific purposes. This plan has been already completed for

those during April 1985 to March 1990, and we have revealed basic characteristics of water quality in Tokyo Bay using a time series seasonal adjustment method. (Ninomiya et al. (1996a, 1996b, 1997), and Kashiwagi (1997)). To analyze the Tokyo Bay data in more detail, we are developing state space

models for space time smoothing and for space time seasonal adjustment.

- **On groundwater inverse analysis:**

  In Town of Muikamachi situated about 300km north of Tokyo, groundwater head has been measured by the related local governments every 6 hours at scores of monitoring points as measures against the sinking ground. To estimate the aquifer system from observed groundwater heads, it is necessary to solve an illposed space time inverse problem. To solve the problem, we developed a Bayesian method (Honjo and Kashiwagi (1999)).

— Plan

I am now interested in inverse problems in remote sensing and in prediction in finance.

— References

Honjo, Y. and Kashiwagi, N. (1999). Matching objective and subjective information in groundwater inverse analysis by Akaike Bayesian information criterion, *Water Resources Research*, (to appear).

Kashiwagi, N. (1997). A study on seasonal adjustment by state space approach; an application to Tokyo Bay data (in Japanese), *Proceedings of the Institute of Statistical Mathematics*, **45**, 329-342.

Ninomiya, K., Kashiwagi, N. and Ando, H. (1996a). Seasonal characteristics of spatial distributions of water temperature and salinity in Tokyo Bay (in Japanese), *Journal of Japan Society on Water Environment*, **19**, 480-490.

Ninomiya, K., Kashiwagi, N. and Ando, H. (1996b). Seasonal characteristics of spatial distributions of COD and DO in Tokyo Bay (in Japanese), *Journal of Japan Society on Water Environment*, **19**, 741-748.

Ninomiya, K., Kashiwagi, N., Ando, H. and Ogura, H. (1997). Seasonal characteristics of spatial distributions of dissolved inorganic nitrogen and phosphorus in Tokyo Bay (in Japanese), *Journal of Japan Society on Water Environment*, **20**, 457-467.

Yoshinori KAWASAKI

— Keywords

seasonality, multifactor models, cointegration, high-frequent data in finance

— Research

Among many time series issues, my research interest is mainly focused on two fields. One is seasonal adjustment or modelling seasonality of economic time series, another is financial time series analysis. Hereafter I briefly state how the research projects have been for the past four years.

- **Modelling seasonality**
  Kawasaki and Sato (1998) characterizes the 'optimality' of seasonal adjustment methods and makes empirical comparison between Kitagawa's DECOMP and the Census Bureau's X-12- ARIMA. Kawasaki and Franses (1996) proposes an alternative approach to test seasonal unit roots.

- **Topics in financial time series**
  Most of the works mentioned here are the results of cooperative research projects. Kawasaki, Sato and Tachiki (1998) discusses a state-space modelling of multifactor stock return models. This project is an outcome from the joint projects with The Nikko Securities, Co. Ltd. Another project was running about the long/short portfolio strategy via cointegration relationship. As this research is just finished in last December, only an interim report for the Nikko Securities is available, and English version is now in preparation. Different line of research on high-frequent data from foreign exchange markets has been proceeded in cooperation with professor Susai (Nagasaki University) and professor Kuwana (Hitotsubashi University). Susai, Kuwana and Kawasaki (1998) is our first outcome, and we expect this will lead to a series of research in coming years.

— Plan

At least for three years ahead, my research interest will remain more or less the same. Kawasaki and Sato (1998) brought me some new insights on the properties of various seasonal models used in the structural time series models or unobservable components ARIMA models, which will shed another lights on the properties of seasonally adjusted data by these model based methods. Empirical comparisons will be carried out under the cooperation with the U.S. Census Bureau, for the cooperative research project with them is determined to be continuously supported by Monbusho until March 2002. Regarding financial time series, I will put much stress on the applied works about foreign exchange market data in the next year.

— References

Kawasaki, Y. and P.H.B.F. Franses (1996), A Model Selection Approach to Detect Seasonal Unit Roots, Tinbergen Institute Discussion Paper Series TI96-180/7.

Kawasaki, Y. and S. Sato (1997), On the 'Optimality' of Seasonal Adjustment Procedures (in Japanese), Proceedings of the Institute of Statistical Mathematics, Vol.45, No.2, p.245–263.

Kawasaki, Y., Sato, S. and Tachiki, S. (1998), A Smoothness Prior Approach to Estimate Large Scale Multifactor Models, ISM Research Memorandum No. 714.

Susai, M., Kuwana, Y. and Kawasaki, Y. (1998), On the Effects of Scheduled Announcements on Foreign Exchange Markets (in Japanese), submitted to the Journal of Japan Financial Association.

Genshiro KITAGAWA

— Keywords

Non-Gaussian State Space Modeling, Filter/Smoother, Information Criterion

— Research

- **Development of non-Gaussian nonlinear filtering/smoothing algorithms.**

  I proposed use of general state space model for the analysis of nonstationary, nonlinear and/or non-Gaussian time series models and developed various filtering and smoothing methods.

  In [10] (JASA 1987), a smoothing formula for non-Gaussian filtering and smoothing formula were developed and were realized by sing numerical integration. The method was applied to the analysis of nonstationary time series. In [11] (SS 1991), it was shown that the same method can be used for nonlinear filtering and smoothing and can yields better results than the conventional filtering algorithms. In [13] (AISM 1994), Gaussian-sum (Gaussian-mixture) smoother was developed and was applied to non-Gaussian seasonal adjustment. In [14] (JCGS 1996), a novel filtering and smoothing method were developed for filtering and smoothing of complex high-dimensional system. They were developed by using by Monte Carlo method, namely by approximating the conditional distributions by many particles. In [18] (JASA 1998), a self-organizing state space model was developed which achieves the estimation of unknown state vector and structural parameters simultaneously.

- **Nonstationary time series modeling**

  I developed various nonstationary models. Most of them were developed by using state space representation of structural time series models. In [1](AISM 1979), a computationally efficient fitting procedure of fitting locally stationary AR model was developed based on the Householder transformation. This method was later used for the implementation of automatic procedure for the estimation of arrival time of seismic waves and the estimation of the location of the epicenters at Meteorological Agency and Hokkaido University [12] (AISM 1991) etc.. In [3] (JTSA 1991), a state space method for trend estimation, seasonal adjustment and structural decomposition was developed. A method of estimating time-varying AR model and changing spectrum was developed in [5] (JSV 1993). This method was extended to the case of time-varying hyper-parameter and was applied to the analysis of seismic data in [8] (IEEE-ac 1985).

- **Signal extraction problems in Seismology**

  Various methods of automatic processing and signal extraction for seismic data were developed based on nonstationary time series modeling. In [9] (SP 1985), we developed a method of extracting small signal from noisy data by using state space model. In [12] (AISM 1991), a computationary efficient method of estimating multivariate locally stationary AR model was developed and applied to the estimation of arrival time of very low S/N signal or S-wave in P-wave. Analysis method of ground water level data was developed in [15] (JASA 1996) where a non-Gaussian state space model was used for the estimation of missing observation and correcting for outlying observation. A structural model was then used to remove the effects of air pressure, earth tide and precipitation. By this development, it became possible to fully utilize the huge amount of past data obtained since 1981. The developed softwares are now distributed from Geological Survey of Japan.

- **Seasonal adjustment method and analysis of financial/economic data**

  A state space decomposition method was applied to the development of seasonal adjustment method and estimation of stochastic volatility of economic time series. In [6] (JBES

1983), the prediction with a structural time series model was considered and the predictive likelihood was proposed. [7] (JASA 1984) summarized the research at the Census Bureau. The Seasonal adjustment program DECOMP ([S3]) was developed by this method.

- **Generalized information criterion**

  We developed information criteria which extend the area of application of AIC. Generalized Information Criterion, GIC, [16] (Biometrika 1996) is an extension of AIC and TIC criterion which can be applied to any estimator defined by statistical functional. Extended Information Criterion, EIC, [17] (AISM 1997) evaluates the bias of log-likelihood by bootstrapping and can be applied to wide class of statistical model and estimation procedures. Recently the method of GIC was extended to higher order correction of the bias term. The method was also used to theoretical analysis for the reduction of bootstrap variance in EIC.

- **Development of statistical controller of ships**

  We developed a practical autopilot system for ships ([2]) based on the multivariate AR model and the stochastic control method developed by Akaike and Nakagawa. The method was commercialized by Mitsui Shipbuilding Co..

- **Outlier detection and correction**

  We developed a procedure for the detection and correction of outliers [4] (Technometric 1978).

— Plan

- **Self-organization in time series modeling**

  In time series modeling, a typical method of identifying a time series model is to represent the model in state space form, compute the likelihood of the model by filtering, estimate the unknown parameters by the maximum likelihood method and find the best model by model selection. In [18], I developed a method which enables to perform the first two steps simultaneously. Currently I am considering a method of estimating even the noise distribution of the state space model simultaneously.

- **Analysis of Array Data**

  In earth science, it is necessary to develop a method of identifying underground structure and extract necessary information from array-data. By cooperative research programs, we have access to both actual observed data and experimental data.

- **Analysis of Multivariate Systems**

  Already 30 years has been past since Prof. Akaike developed a method of analyzing stationary linear systems with feedback loops. Recently, the analysis of interrelation between components of nonstationary or nonlinear systems. I would like to develop a practical method of analyzing multivariate nonlinear or nonstationary systems.

- **Contribution to Information Science and Discovery Science**

  Statistical science can be considered as an important part of information science and I believe that the statistical methods, especially the statistical modeling, can contribute to various fields in information science such as Discovery science.

- **Information Criterion**

  Information criterion is a very useful criterion in modeling. However, its application is limited to the model estimated by the maximum likelihood method. We already succeeded in extending the area of application by GIC (to functional statistics) and by EIC (based on bootstrap method). We are now planning to apply the method of GIC to Bayesian models.

— References

[1] G. Kitagawa and H.Akaike, (1978). A procedure for the modeling of non-stationary time series. *Annals of the Institute of Statistical Mathematics*, **30-B** 351-363

[2] K.Ohtsu, M.Horigome and G. Kitagawa,(1979). A new ship's auto pilot design through a stochastic model. *Automatica*, **15** 255-268.

[3] G. Kitagawa (1981). A nonstationary time series model and its fitting by a recursive filter. *Journal of Time Series Analysis*, **2** 103-116

[4] G. Kitagawa (1979). On the use of AIC for the detection of outliers. *Technometrics*, **21** 193-199. (Corrigenda: **23** (1981) 320-321)

[5] G. Kitagawa (1983). Changing spectrum estimation. *Journal of Sound and Vibration*, **89** 433-445

[6] W.Gersch and G. Kitagawa(1983). The prediction of time series with trends and seasonalities. *Journal of Business & Economic Statistics*, **1** 253-264.

[7] G. Kitagawa and W.Gersch(1984). A smoothness priors-state space approach to the modeling of time series with trend and seasonality. *Journal of the American Statistical Association*, **79** 378-389.

[8] G. Kitagawa and W.Gersch(1985). A smoothness priors-time varying AR coefficient modeling of nonstationary covariance time series. *IEEE Transactions on Automatic Control*, **30** 48-56.

[9] G. Kitagawa and T.Takanami(1985). Extraction of signal by a time series model and screening out micro earthquakes. *Signal Processing*, **8** 303-314.

[10] G. Kitagawa (1987). Non-Gaussian state-space modeling of nonstationary time series. *Journal of the American Statistical Association*, **82** 1032-1063.

[11] G. Kitagawa(1991). A nonlinear smoothing method for time series analysis, *Statistica Sinica*, **1** 371-388.

[12] Takanami and G. Kitagawa(1991). Estimation of the arrival times of seismic waves by multivariate time series model, *Annals of the Institute of Statistical Mathematics*, **43** 407-433.

[13] G.Kitagawa(1994). The two-filter formula for smoothing and an implementation of the Gaussian-sum smoother, *Annals of the Institute of Statistical Mathematics*, **46** 605–623.

[14] G. Kitagawa(1996). Monte Carlo filter and smoother for non-Gaussian nonlinear state space models, *Journal of Computational and Graphical Statistics*, **5** 1–25.

[15] G. Kitagawa and Matsumoto, N.(1996). Detection of Coseismic Changes of Underground Water Level, *Journal of the American Statistical Association*, **91** 521–528.

[16] Konishi, S. and G. Kitagawa(1997). Generalized information criteria in model selection, *Biometrika*, **83** (1996) 875-890.

[17] Ishiguro, M. and Sakamoto, Y. and G. Kitagawa, Bootstrapping log likelihood and EIC, an extension of AIC, *Annals of the Institute of Statistical Mathematics*, **49** 411-434.

[18] G. Kitagawa(1998). Self-Organizing State Space Model, *Journal of the American Statistical Association*, **93** 1203–1215.

Junji NAKANO

— Keywords

Graphical user interface, Internet, Knowledge engineering, Statistical package

— Research

I am interested in designing user-friendly statistical packages or statistical analysis environments using new computer technologies. I have started three projects.

First one is applying knowledge engineering techniques to statistical software. We made a regression analysis supporting system (named RASS), which has a knowledge database about statistical methods in it, and gives appropriate advice to the user. This is so called statistical "expert system". We adopted the object oriented design for building this system.

Second project is a use of the Internet environments from statistical packages. We implemented a graphical user interface (GUI) on the SHAZAM statistical package, which I used for teaching time series analysis in Hitotsubashi University. This GUI are realized by Tcl/Tk language, and server/client mechanism. It can be used as stand-alone program as well as from inside of Web browsers. It also adds the simple distributed parallel computing ability to SHAZAM.

Third project is constructing a new GUI for statistical packages. Almost all modern statistical packages have their GUIs based on their old command languages. Although this approach has a lot of merits for both programmers and users, GUIs are used mainly for generating their command languages in such packages. For using full merits of GUI, we had better to design a statistical package from the beginning considering GUI. Our time series analysis supporting system TISAS was designed for GUI which displays the analysis history. It shows data, statistics and models by icons, and they are located for expressing the analysis history intuitively and have well organized pull down menus.

— Plan

First, I will continue above three projects. For the RASS project, we redesigned it using agents instead of objects for its basis. Our agents are new objects with knowledge. We hope this redesign will increase system flexibility and extendibility. For the Internet usage, we think more advanced distributed parallel computing in statistical computations. Although there exists many distributed computing techniques already, they are too complicated and difficult to use for statistical computations. I will design the easy distributed parallel computing mechanism. For

the TISAS project, we will use results of the former two projects in it. Client/server approach will be the part of TISAS. Distributed computing ability will be added to it. Second, we know all three projects concerns the statistical data representation in computer software. Their results can be connected mutually in one system in future. Third, as I become a member of this group in ISM, I will re-organize programs by other members based on above results. It will make the programming works of our group easy to access.

— References

A knowledge-based multiple regression analysis supporting system (with Y. Yamamoto and M. Okada), Japanese Journal of Applied Statistics, Vol. 20, pp. 11-23 (in Japanese), 1991.

Object oriented knowledge representation for multiple regression analysis (with Y. Yamamoto and I. Kobayashi), Short communications in computational statistics 1994 (ed. R. Dutter and W. Grossmann), pp.156–157, 1994.

RASS : Software using object oriented knowledge representation for multiple regression analysis (with Y. Yamamoto and I. Kobayashi), Proceedings in computational statistics 1994 software descriptions (ed. R. Dutter and W. Grossmann), pp.55–56, 1994.

Porting TIMSAC72 for MS-Windows to UNIX (with Y. Yamamoto and Y. Tamura), Proceedings of the Institute of Statistical Mathematics, Vol. 43, No.2 pp. 285–292 (in Japanese), 1995.

Programming language of a regression analysis supporting system RASS (with I. Kobayashi), Proceedings of the Institute of Statistical Mathematics, Vol. 45, No.1, pp.1–11 (in Japanese), 1997.

WWW interface of the statistical package SHAZAM (with K. White), Proceedings of the Institute of Statistical Mathematics, Vol.45, No.1, pp. 41–47 (in Japanese), 1997.

An Internet user interface for statistical software, Bulletin of the International Statistical Institute, 51st session, Contributed papers book 2, pp.35–36, 1997.

An object oriented graphical user interface for time series analysis (with Y.Yamamoto), Bulletin of the International Statistical Institute, 51st session, Contributed papers book 2, pp.449–450, 1997.

Graphical user interface for statistical software using Internet, COMPSTAT 1998 Proceedings in Computational Statistics (ed. R. Payne and P. Green), pp. 407–412, 1998.

Yosihiko OGATA

— Keywords

Aftershocks, Real-time discrimination of foreshocks, Epidemic type Aftershock Sequence (ETAS) model, Great earthquakes, Modified Omori formula, Magnitude, Paleoearthquakes, Precursor to large earthquake, Relative quiescence, Seismicity anomaly, Space-time point processes, Statistical point-process models.

— Research

Research on Statistical analysis of earthquake catalog by the ETAS point-process model and its space-time extensions

A major earthquake is followed by many aftershocks. In many cases aftershock1 sequence is more complex than the simple inverse power decay expected by the modified Omori formula. The Epidemic Type Aftershock-Sequences (ETAS) point-process model is a magnitude-dependent superposition of the modified Omori formula and well fitted not only to various aftershock sequences including non-volcanic type swarms but also general seismicity in a geophysical region. I have made applications of the ETAS model to geophysical problems including the analysis of seismic quiescence as a possibly useful precursor to large earthquakes. Also, extensions of the ETAS models to apply the space-time hypocenter data is discussed and compared toward the practical use. In the following the summaries of our relevant works are described:

- **Quiescence Relative to the ETAS Model** (Ogata, 1998) The anomaly in focus is *relative quiescence* which is defined as a significant decrease of earthquake activity compared with the predicted occurrence rate by the estimated ETAS model for the standard seismicity of the region. Regardless of the seismicity level, the relative quiescence can take place.

  Size of such quiescence is seen in cumulative and M-T (magnitude versus time) diagrams of transformed occurrence times by using the estimated ETAS model. By this method, we recognize significant, relatively quiet stages in shallow seismicity over M5 class in a very wide area preceding all studied great earthquakes of M8 class in and around Japan and also those of M9 class in the world. However, we saw no relative quiescence for about 20 years up to 1990 in the wide areas which include the Tokai and Boso gaps. On the other hand, a few authors recently showed a very significant quiescence for the last 20 years since early or mid 1970's in the seismicity of certain areas in or around Tokai region. However, it turns out that these quiescence are seeming ones owing to magnitude shifts which took place during 1975$\sim$76. The magnitudes below M_J 5.0 are substantially underestimated after the period. This shift is found and estimated by a statistical comparison of magnitudes between the JMA and USGS catalogs. Nevertheless, the recent seismicity with level of $M_J \geq 5.5$ in a very wide region including central and western Japan shows a significant relative quiescence since 1992, which may be related to the 1995 Kobe Earthquake of $M_J 7.2$.

- **Statistical relations between the parameters of aftershocks in time, space and magnitude**(Guo and Ogata, 1997)

  The correlation between characteristic parameters of statistical models, such as the b-value of the magnitude distribution, the p-value of the modified Omori formula for aftershock decay rate, the p- and α-value of the $ETAS$ point process model, and the fractal dimension D of the spatial hypocenter distribution, is analyzed for 34 aftershock sequences in Japan from 1971 to 1995. All the parameters are estimated using maximum likelihood methods with their error assessments. For the majority of the aftershock sequences, the $ETAS$ model has a smaller AIC than the non-stationary Poisson models with the modified Omori formula, which suggests existence of further clusters within the aftershock sequence. Most of the scatter plots between the maximum likelihood estimates of the characteristic parameters are seen to be either positively or negatively correlated. The contrasting correlation patterns are revealed between the parameters for the intraplate and interplate earthquakes

except the two pairs (b, D) and (α, p) where the similar patterns are found. We then focus our attention on these patterns as a source of interesting contrasts between the two earthquake groups. In particular, the significant dependence of these parameters on the depth appears a key to understand the correlation pattern for interplate aftershocks, while a different interpretation have to be given for intraplate aftershocks because no dependence on depth is seen.

- **Space-Time Point-Process Models for Earthquake Occurrences** (Ogata, 1998)

  The ETAS model, as the standard model for seismicity, has been successfully applied for the detection of anomalous change of the seismic activity. However, since the ultimate objective of earthquake prediction is to indicate the location of the anomalous area corresponding to the temporal anomaly, it has been required to develop useful statistical models for identifying the space-time seismic activity properly using hypocenter catalogs of earthquakes. Several possible extensions of the ETAS model to apply space-time data are considered based on classical empirical studies of aftershocks in space and time. We will discuss the discrimination of these models which represent the contrasts of physical nature of the space-time clustering. Further practical extensions of the models are suggested to apply the data including non-homogeneous background seismicity and anisotropic features of earthquake clusters. Goodness-of-fit of these models is measured by AIC for two data sets from the areas of tectonically distinctive features. From the AIC comparison of models, certain clustering features in space are clarified. Simulation algorithm for the models is provided and implemented to justify the accuracy of the likelihood calculation including the boundary effect. The simulated data sets show the similar spatial distribution to the real ones, but also show some discriminating space-time patterns from the real ones, which probably relate important subject of our further study.

- **Real-Time Statistical Discrimination of Foreshocks From Other Earthquake Clusters** (Ogata et al., 1996)

  When earthquake activity begins at some place, it may be a foreshock sequence of a larger earthquake, or it may be a swarm or simple mainshock-aftershock sequence. This paper is concerned with the conditional probability that it will be foreshock activity of a later larger earthquake, depending on the occurrence pattern of some early events in the sequence. The earthquake catalogue of the Japan Meteorological Agency (1926$\sim$1993, $M_J \geq 4$) is decomposed into numbers of clusters in time and space to compare statistical features of foreshocks with those of swarms and aftershocks. Using such a data set, we reveal some discriminating features of foreshocks relative to the other type of clusters, for example the events' stronger proximity in time and space, and a tendency towards chronologically increasing magnitudes, which encouraged us to construct models which forecast the probability of the earthquakes being foreshocks. Specifically, the probability is a function of the history of magnitude differences, spans between origin times and distances between epicenters within a cluster. For an illustrative implementation, the models were fitted to the early part of the data (1926$\sim$1975) and the validity of the forecasting procedure were checked on data from the later period (1976$\sim$1993). Two procedures for evaluating the performance of probability forecast are suggested. Further, in the very beginning of an activity where only a single event is available (i.e., either it is the first event in a cluster or a single isolated event), we also forecast the probability of the

event being a foreshock as a function of its geographic location. Then, the validation of the forecast is demonstrated in a similar manner. Finally, making use of the multi-elements prediction formula, we see that the forecasting performance is enhanced by the joint use of the information in the location of the first event, and that in the subsequent inter-event history in the cluster.

— Plan

- **Estimating the hazard of rupture using uncertain occurrence times of paleoearthquakes** (Ogata, 1999)

  Our main concern is analysis of the data in which some occurrence times of events themselves are uncertain and given by intervals or some distributions. Specifically, we consider a Bayesian inference where each uncertainty is interpreted as a prior distribution associated with likelihood of a renewal process model. Integration of the posterior with respect to the occurrence times and its maximization with respect to the the parameters of the renewal process model are implemented in order to estimate the parameters and further to compare the goodness-of-fit of other competing renewal process models. Thus the posterior of the selected model provides a reasonable estimate of distribution of uncertain occurrence times associated with the fitted renewal process model. Finally, in case where occurrence time of the last event is uncertain, a practical method for the assessment of current and future hazard of the forthcoming rupture is provided.

- **Relative Quiescence in Aftershock sequences and Swarms Preceding to Large Earthquake in the Neighboring Region** (Ogata, 1999)

  In this paper, we focus on a number of aftershock sequences and swarms which preceded the neighboring large earthquakes, to examine whether or not we can find the *relative quiescence* which is defined as an significant seismicity lowering from the occurrence rate expected by the estimated ETAS model. Regardless of the seismicity level, the relative quiescence can take place.

  Size of such quiescence if exist is seen in cumulative and M-T diagrams of transformed occurrence times by using the estimated ETAS model. By this method, in most cases, we recognize significant relatively quiet stages in the studied sequences preceding another large event near to the source region in and around Japan. We also investigate aftershock sequences of large or great events which are normally decreased. Most of them are not shortly followed by another large events in the neighborhood. It is thus hoped that the relative quiescence can be helpful to discriminate the aftershocks and swarms whether or not a large event shall follow shortly in the neighborhood.

— References

Ogata, Y., Utsu, T. and Katsura, K. (1996). Statistical discrimination of foreshocks from other earthquake clusters, *Geophys. J. Int*, **127**, 17-30.

Ohsuka, S.,Ogata, Y. and Tamura, Y. (1997). Application of point-process model to occurrence-time data of photomultiplier dark pulses, *Nuclear Instruments and Methods in Physical Research*, **A384**, 477-481.

Guo, Z. and Ogata, Y. (1997). Statistical relations between the parameters of aftershocks in time, space and magnitude, *J. Geophys. Res.*, **102**, No. B2, 2857-2873.

Utsu, T. and Ogata, Y. (1997). Statistical analysis of seismicity, in "Algorithms for Earthquake Statistics and Prediction", IASPEI Software Library, **6**, 13-94, International Association of Seismology and Physics of the Earth's Interior.

Ogata, Y. (1998). Quiescence relative to the ETAS model, in Special Issue on Long-Term Earthquake Forecasts *Zisin (Journal of the Seismological Society of Japan)*, 2nd series, 115-127, in Japanese.

Ogata, Y. (1998). Space-time point-process models for earthquake occurrences, *Ann. Inst. Statist. Math.* **50**, 379-402.

Ogata, Y., Kobayashi, A., Mikami, N., Murata, Y. and Katsura, K. (1998). Correction of earthquake location estimation in a small-seismic-array system, *BERNOULLI* **4**, 167-184.

Ogata, Y. (1999). Estimating the hazard of rupture using uncertain occurrence times of paleoearthquakes, *Res. Memo. No. 702*, Inst. Statist. Math., the revision is submitted to *J. Geophys. Res.*

Ogata, Y. (1999). Relative Quiescence in Aftershock sequences and Swarms Preceding to Large Earthquake in the Neighboring Region, in preparation.

Tohru OZAKI

— Keywords

Nonlinear Predictions, Nonlinear Time Series, Non-Gaussian Time Series, Innovations, System Identifications, Nonlinear Control, Nonlinear Vibrations, Limit Cycles, Chaos, Nonlinear Dynamical Systems, ExpAR Models, State-dependent AR Models, RBF-AR Models, Diffusion Processes, Stochastic Differential Equations, Nonlinear Filters, Local Linearizations, Maximum Likelihood Method

— Research

In 1976 I had an idea to organize the three different types of dynamic models, i.e. nonlinear time series models(including nonlinear AR models and nonlinear state space models), nonlinear stochastic differential equation models and nonlinear dynamical system models, together so that we can take advantage of the merit of each type of models for the analysis of time series data.

From this idea I first introduced a nonlinear AR model which has similar characteristics as the nonlinear random vibration models such as stochastic van der Pol equation models and stochastic Duffing type vibration models. Important point for the nonlinear AR type modelling is the stability and stationarity. Most polynomial type AR models, although they are useful for prediction, computationally explode in simulations and fail to produce similar time series as the original data. To solve the instability problem in simulations I introduced a model which has computational stability by utilizing a exponential function for the state dependent AR coefficient. The model was later called Exponential AR model in Prof.M.Priestley's famous textbook. I noticed that the ExpAR model shares a lot of common characteristics with a stochastic dynamical system models dx/dt =f(x)+n(t), driven by white noise n(t). This convinced me that the two models, ExpAR models and stochastic differential equation models are closely related.

I tried to find a discretization scheme which could bring from a stochastic dynamical system model, an ExpAR type time series model automatically, and lead to the idea of the local linearization scheme. At the same time I found that there is an interesting close relationship between diffusion processes, stochastic differential equation models and Pearson systems defining a certain class of probability density functions. I found that ExpAR models can be used, through these relations, to capture all these properties characterized by stochastic differential equation models in nonlinear and non-Gaussian time series data. Thus any time series with a certain non-Gaussian marginal distribution can be generated by a ExpAR model combined with a variable transformation.

On the other hand I showed that the multi-dimensional nonlinear dynamical system models, including most continuous time chaos models, can be identified directly from scalar time series data. The local linearization scheme provides us with a method to obtain, from a continuous time multi-dimensional dynamical system model, a discrete time nonlinear state space representation. By using a nonlinear filtering technique we can have a maximum likelihood method for the nonlinear state space model. The idea which played essential role in deriving the local linearization can be also used for deriving a computationally stable and efficient nonlinear filtering scheme for the nonlinear state space model. The method was applied to several examples of dynamical system models in various scientific fields such as neurosciences, financial mathematics, and meteorology.

— Plan

I think the triangle approach of the three types of dynamic models, time series models, stochastic differential equation models and dynamical system models, can have tremendous potential in the future development of time series analysis of complex high-dimensional dynamic phenomena. Obvious examples are financial mathematics recently developed on the basis of Ito stochastic differential calculus. Adapting the mathematical models to real financial data is one of the most important works expected in this field. Another example is neurosciences where various nonlinear dynamical system models have been developed. Meteorology is another example where dynamical system models play significant role, while pragmatic purpose of weather prediction using the observed time series is also urgent issue. The triangle approach to the analysis of these nonlinear dynamic phenomena is still in the early stages of development. Combination of recently developed computational techniques and potential of super computer will certainly contribute to the increase of the power of the present approach.

— References

Shi,Z, Tamura, Y. and Ozaki,T.(1998) "Some examples on reconstructing nonlinear dynamics by the generalized exponential autoregressive model", Proc. of the Fourth Int. Symposium on Artificial Life and Robotics, Oita, Japan, 19-22, January, 1999.102-105.

P.Thomson and T.Ozaki(1998), "Transformation and seasonal adjustment", Research Memorandum, No.706, Institute of Statistical Mathematics, Tokyo, 1998.

T.Ozaki and P.Thomson(1998), " A dynamic nonlinear model for X-11", Research Memorandum, No.707, Institute of Statistical Mathematics, Tokyo, 1998.

T.Ozaki, J.C.Jimenez, R.Biscay and P.Valdes(1998) "Nonlinear Time Series Models and Neural Dynamical Systems", Research Memo. No.657, Institute of Statistical Mathematics, to

appear in "Nonlinear Dynamics & Brain Functioning", Nova Science Publishers, edited by N.Pradhan, P.E.Rapp & R.Sreenivasan

P.Valdes, J.Bosch, J.C.Jimenez, N.Trujillo, R.Biscay, F.Morales, J.L.Hernandez, T.Ozaki(1998), "The Statistical Identification of Nonlinear Brain Dynamics: A Progress Report", Research memorandum No.705, Institute of Statistical Mathematics, Tokyo, 1998. to appear in "Nonlinear Dynamics & Brain Functioning", Nova Science Publishers, edited by N.Pradhan, P.E.Rapp & R.Sreenivasan

Z.Shi, Y.Tamura and T.Ozaki(1998) "Nonlinear time series modeling by radial basis function-based state-dependent autoregressive model", International Journal of Systems Science, to appear.

Z.Shi, Y.Tamura and T.Ozaki(1998) "A study on real-time detecting of machine tool chatter", International Journal of the Japan Society for Precision Engineering, to appear.

Z.Shi, Y.Tamura and T.Ozaki(1998) "RBF neural network is more suitable for function approximation than modeling in nonlinear time series analysis", in Proceeding of the Fifth International Conference on Neural Information Processing, Kitakusyu, Japan, October 21-23, 1998, 1045-1048.

J.C.Jimenez, I.Shoji and T.Ozaki(1998) "Simulation of stochastic differential equations through the local linearization method. A comparative study", J. of Statistical Physics, to appear

Shoji, I. and Ozaki, T.(1998) "Estimation for nonlinear stochastic differential equations by a local linearization method", Stochastic Analysis and Applications, 16, 733-752, 1998.

Shoji, I. and Ozaki, T.(1998) "A statistical method of estimation and simulation for systems of stochastic differential equations", Biometrika, 85, 240-243, (1998),

T.Ozaki(1998) "Dynamic X11 and Nonlinear Seasonal Adjustment 1", Proceeding of the Institute of Statistical Mathematics, 45, 265-285, (in Japanese).

T.Ozaki(1998) "Dynamic X11 and Nonlinear Seasonal Adjustment 2", Proceeding of the Institute of Statistical Mathematics, 45, 287-300, (in Japanese).

Valdes,P.A. ,Jimenez,J.C., Riera,J., Biscay,R. and Ozaki,T.(1997) "Nonlinear EEG Analysis based on Neural Mass Model", Research Memo. No.652, Institute of Statistical Mathematics, Tokyo. to appear in Biological Cybernetics.

Jimenez, J.C. and Ozaki, T.(1997) "Identification of continuous-discrete state space models with delays", Research Memo. No.658, Institute of Statistical Mathematics.

Shoji, I. and Ozaki(, T.1997) "Comparative study of estimation methods for continuous time stochastic processes", Journal of Time Series Analysis, 18, 485-506., (1997),

Biscay, R., Jimenez, J.C., Ozaki, T., JRiera, J., Valdes, P.(1997) "The local linearization method for stochastic differential equations: Properties and applications" In the Proceeding of the 24th international congress "Stochastic Processes and Applications" (SPA24), 16-20 june, 1997 Chile, organized by the Bernuolli Society for Mathematical Statistics and Probability.

Toyoda, Y., Oda,K. and Ozaki,T. (1997) "The nonlinear system identification method for advanced control of the fossil power plants." In Proc. of 11th IFAC Symposium on System Identification, 8-11, July 1997, Kitakyusyu, Fukuoka, Japan.

Ozaki,T., Valdes-Sosa, P. and Ozaki, V.H.(1997) "Reconstructing Nonlinear dynamics from time series : with Application to Epilepsy Data Analysis", Manchester University/UMIST Technical Report, 1997/02

Seisho SATO

— Keywords

Seasonal Adjustment, WWW, Decomp, State Space

— Research

I developed the statistical software named "Web Decomp". In this system, the users can analyze their own data and do seasonal adjustment without installing any softwares. An important feature of Web-DECOMP system is that it is a WWW site of the Internet and most of the computation can be done by server machine, not by user's computers. This system is based on "DECOMP" (Kitagawa and Gersch(1985)) and "TIMSAC".

— Plan

The concept of "Web Decomp" is "easy to use". But I think that we should also develop the normal statistical software which has "GUI". I will develop "S-Decomp" which is run on S language.
Also, I plan to modify "Decomp" in the following way.

[1] Adding the option to make an adjusted series more stable.

[2] Adding the option to detect the outliers in the original series.

[3] To extend this method to the multivariate cases.

[4] To propose the robust year on year change (or month on month).

I think that we will need the more accurate adjusted series for the economic time series and the small error caused by the adjustment can be a big problem, because the growth rate of Japanese economy is getting lower and the economic time series in Japan have a less heavy trend than before.

— References

S. Sato, (1997) Introduction to "Web Decomp" — Seasonal Adjustment system on WWW —, Proceedings of the Institute of Statistical Mathematics, Vol.45, No.2, 233–243, (Japanese)

Makoto TAIJI

— Keywords

Special-purpose computers, Complex system

— Research

- **Special-purpose computers**
  We have developed special-purpose computers for scientific simulations, for example, molecular-dynamics simulations, astrophysical N-body problems, Monte Carlo simulations of Ising spin systems, and so on. Among them, GRAPE-4 achieved the teraflops speed first in the world. We have also developed the new physical random number generator.

- **Complex systems**
  We studied the dynamics of game player who build the opponents' model. The players build the models by recurrent neural networks which can imitate the time-series of the opponents' actions. The iterated prisoner's dilemma game has been studied. The complex transients were observed because of the indeterministic nature of the models.

— Plan

- **Special-purpose computers**
  We start the design of the semi-general-purpose computers which can accelerate dense matrix calculations, classical particle simulations, and dynamic programming. A ultra-high-precision microprocessor which can directly operate octuple (or more) precision numbers is also interested.

- **Complex systems**
  Games with complex symbols are interested to study the evolution of the linguistic communication. Also, the Hamiltonian dynamics of glassy system is also of interest.

— References

Taiji, M., Ito, N. and Suzuki, M. (1988). Special-purpose computer system for Ising models, *Rev. Sci. Instrum.*, **59**, 2483-2487.

Taiji, M., Makino, J., Ebisuzaki, T., and Sugimoto, D. (1994). GRAPE-4: a teraflops massively parallel special-purpose computer system for astrophysical N-body simulations, *Proc. 8th International Parallel Processing Symposium*, IEEE Computer Society, 280-287.

Makino, J. and Taiji, M. (1996). Computational Astrophysics on a special-purpose machine, *Computers in Physics*, **10**, 352-358.

Taiji, M., Makino, J., Fukushige, T., Ebisuzaki, T., and Sugimoto, D. (1996). GRAPE-4: a teraflops machine for N-body simulations, *Dynamical Evolution of Star Clusters*, International Astronomical Union , 141-150.

Fukushige, T., Taiji, M., Makino, J., Ebisuzaki, T., and Sugimoto, D. (1996). A Highly-Parallelized Special-Purpose Computer for Many-body Simulations with An Arbitrary Central Force: MD-GRAPE, *Astrophysical Journal*, **468**, 51-61.

Makino, J., Taiji, M., Ebisuzaki, T., and Sugimoto, D. (1997). GRAPE-4: A massively-parallel special-purpose computer for collisional N-body simulations, *Astrophysical Journal*, **480**, 432-441.

Makino, J. and Taiji, M. (1998). Scientific Simulations with Special-Purpose Computers, John Wiley & Sons, Chichester.

Ikegami, T. and Taiji, M. (1998). Structures of Possible Worlds in a Game of Players with Internal Models, *Acta Polytechnica Scandinavica*, **91**, 283-292.

Sato, Y., Taiji, M., and Ikegami, T. (1998). Self-similar sets as satisfiable Boolean expressions, in *Unconventional Models of Computation*, Springer-Verlag, 352-370.

Taiji, M. (1999). Dynamics of Internal Models in Game Players, Physica D, in press.

Yumi TAKIZAWA

— Keywords

Personal radio communications, Code Division Multiple Access (CDMA), Wideband Spreading

— Research

Personal radio communications have been one of the most interested themes in the public telecommunications area supported satellite ground location. The number of subscribers for mobile cellular and cordless telephones are increasing rapidly and these system capacities are close to saturation. Spectrum utilization in multiple user applications (multiple access : MA) is considered by assigning a unique frequency, time, or code to each user channel. These methods are called Frequency Division (FDMA), Time Division (TDMA), and Code Division Multiple Access (CDMA) respectively. Channel separations in frequency or time decreases system capacity. Handover operation requires switching of channels in the case of FD and TD, which brings operational complexities and decreasing of system capacity. CDMA system avoids switching of channel frequencies, because every user uses the entire frequency band and each user retains his unique code permanently.

We are studying a wideband direct sequence CDMA (W-CDMA) system. The system uses wideband spreading to accomplish greater immunity, high quality speech and high speed data transmission. The system uses coherent detection (CD) to increase system capacity. CD has been in practice by using continuous pilot signals in forward/reverse links. PN and Hadamard sequences are used as the spreading code for minimal mutual interference among traffic and pilot/sync/paging channels. And the 32 kbit/s robust waveform speech coder COM101+ has been developed to achieve toll quality speech under radio environment.

— Plan

An interference canceler (IC) is required to reduce interference energy in forward link, and expected to enhance the system capacity. The IC system with coherent detection using Pilot channel would become an effective technique for increasing the number of subscribers.

— References

[1]Atsushi Fukasawa, Yumi Takizawa, and Mitsutoshi Hatori (1998). "Basic Understanding on Spread Spectrum Communication and Its Application to Mobile Radio Communications", Journal of Institute of Electronics, Information and Communication Engineers (IEICE), Vol. 81, No. 1, pp. 51-59.

[2] Fukasawa A., Sato T., Takizawa Y., Kato T., Kawabe M. and Fisher R.E. (1996). Wideband CDMA System for Personal Radio Communications, IEEE Communications Magazine, Topics in Personal Communications, Vol.34, No.10, pp. 116-123.

Yoshiyasu TAMURA

— Keywords

audio-visual information processing system, nonstationary time series analysis, TIMSAC, parallel processing, artificial neural networks, physical random numbers

— Research

- An audio-visual information processing system of which construction was originally proposed by Professor H. Akaike in 1980 was developed from 1981 to 1984 with M. Yamada and H. Horai. The following instruments are attached to this system so as to examine the characteristics of large-scale data through the senses of sight and hearing.
  - oscilloscopes
  - loudspeakers
  - XY-plotter

  This system is a realization of what we call multimedia systems in the recent word.
- A Bayesian approach to nonstationary process analysis was studied and computer program for estimating nonstationary spectrum was developed form 1984 to 1986. The model is a kind of the local stationary models. A constraint on the autoregressive coefficients of the successive blocks is considered. With the aid of the minimum ABIC procedure a hyper parameter is estimated.
- The TIMSAC(TIMe Series Analysis and Control) program packages have been developed in the past 25 years. TIMSAC for Windows and for UNIX were developed with J. Nakano and Y. yamamoto form 1993 to 1996.
- Parallelization and vectorization of BAYSEA and TVCAR were studied with M. Ishiguro, G. Kitagawa and A. Okuda in 1989. Parallel processing of statistical data analysis such as multiple regression analysis and principal component analysis was studied with F. Shimodaira, S. Kobayasi and T. Shirakawa in 1994, 1996 and 1997.
- As an application of artificial neural networks, a prediction of the number of leukemic cells was studied from 1993 to 1994. In 1986 a prediction with a Bayesian approach was studied. Results of the both methods are compared.
- The methods for generating physical random numbers were studied. We are prepared to apply for a patent on the physical random number generator which was studied with HITACHI Ltd.

— Plan

Nonlinear time series models and nonstationary time series models will be studied. I also want to develop new program packages on time series analysis but also general multivariate analysis. Hardwares for special purpose computing will be studied.

— References

Y.-H. Tamura (1985), M. Yamada and H. Horai, On an audio-visual Information processing system, *Proceedings of the Institute of Statistical Mathematics*, **33** 101-109.

Y.-H. Tamura (1987), An approach to the nonstationary process analysis, *Annals of the Institute of Statistical Mathematics*, **39B**, 227-241.

Y. Tamura (1994), Applications of TIMSAC, *Proceedings of the First US/Japan Conference on the Frontiers of Statistical Modeling : An Informational Approach*, 251-271, Kluwer Academic Publishers eddied by H. Bozdogan.

Y. Yamamoto ,J. Nakano and Y. Tamura (1995), Porting TIMSAC72 for MS-Windows to UNIX, *Proceedings of the Institute of Statistical Mathematics*, **43**, 285-292.

M. Ishiguro, G. Kitagawa, Y.-H. Tamura and A. Okuda (1990), Parallel and vector programming technique for FORTRAN programs of time series analysis, *ISM Reports on Statistical Computing*, **17**.

F. Shimodaira, S. Kobayashi, T. Shirakawa and Y. Tamura (1995), Parallel processing of statistical data analysis, *Bulletin of the Computational Statistics of Japan*, **8**, 15-26.

Y. Tamura (1995), Neural networks and time series analysis, *The Institute of Statistical Mathematics Cooperative Research Report*, **68**, 165-174.

Kunio TANABE

— Keywords

Probabilistic Reasoning Mechanism, Nonparametric Bayes Models, Model Selection Criteria, Inverse Problems, Stochastic PDE, Numerical Computation, Optimization

— Research

- **Bayesian Modelling of Inverse Problems**
  Kunio Tanabe(KT)'s interest in inverse problems initiated when his numerical analysis paper [1] offered a mathematical base for an earlier development of X-ray Computer Tomography, ART(Harman, Lent and Rowland, 1973). When Akaike introduced the celebrated AIC statistic, KT applied it to a backward heat equation and determined successfully an appropriate number onf node points as well as a degree of B-spline models for a solution of the inverse problem [7]. This method with the variable-nodes-B-spline model was applied also to the small angle X-ray scattering problem in Chemistry [16]. The AIC was also applied to several incorrectly posed linear equations for finding an effective rank of coefficient matrix successfully [6].

  But, KT's methodological emphasis in treating inverse problems shifted toward a nonparametric Bayesian modelling approach from the parametric modelling one because of the former's flexibility in picking up an unforeseen structure. This approach was shown to be very usefull in a seismic tomography for inferring the earth's interior [20], in a diagnostic analysis of the airway resistance in a lung [18], in an estimation of distribution of gas-exchange capacity of a lung [22] and in an analysis of temporal movement of a rendition of a piano music. In these works KT emphasized the use of improper priors and proposed a criterion IPBIC for choosing hyperparameters in such circumstances. KT

obtained interesting applications of IPBIC such as fitting nonparametric surface to data [14] and uni- and bi-variate nonparametric Bayesian density estimation.

- **Development of Algorithms in Numerical Analysis**
  KT developed several new algorithms in numerical algebra, which include a projection methods for singular system of linear equations [1,3], an acceleration algorithm of linear iterative method [2], which is known as adaptive acceleration method (something similar to the Aitken's δ method for a scaler sequence), Tanabe's method for simultaneous iteration for solving an algebraic equations [13], successive rank one modification method for a linear system [24] and algorithms for pivoting in Cholesky method and Gram-Schmidt method. KT has bee also interested in the conjugate gradient method and produced unconventional applications such as computing all the stationary probability vectors of a stochastic matrix [8] and computing the Moore-Penrose inverse of a matrix [8].

- **Centered Newton Method for Numerical Optimization**
  When KT entered the field of numerical optimization in early seventies, there were too many constrained optimization methods. KT was uncomfortable with the deviations in those methods from the classic Lagrangian method and felt a need for a unified principle for designing algorithms for constrained optimization. Through the differential geometric analysis [4,9,11] of dynamical systems of continuous analogues of the Newton method, he came to the conclusion that optimization algorithm should be designed as close as possible to the Newton method applied to a certain equation associated with the pure Lagrange function [12]. Principal approach of KT has always been centered around differential geometric methods, which is now-aday popular but was not so in the past.

  Based on this methodological lines of research, KT developed several methods such as centered Newton methods(presently known as primal-dual interior point methods) together with Tanabe-Todd-Ye Potential Function [17,19] and updating algorithms for an approximate Hessian matrices arising in constrained optimization [12].

— Plan

Combining his expertizes in the fields of Optimization, Numerical Analysis and Statistical Modeling, KT is pursuing the research on the topic of probabilistic reasoning mechanism from a view point of Bayesian modeling and large scale algorithmic computation.

— References

[1] K. Tanabe, (1971). Projection method for solving a singular system of linear equations and its applications, *Numerische Mathematik*, **17** , 203-214

[2] K. Tanabe, (1972). A program for accelerating stationary linear iterative method(in Japanese), *Information Processing*, **13**, 263-266

[3] K. Tanabe, (1974). Characterization of linear stationary iterative processes for solving a singular system of linear equations, *Numerische Mathematik*, **22**, 349-359

[4] K. Tanabe, (1974). An algorithm for the constrained maximization in nonlinear programming, *Journal of Operations Research Society of Japan*, **17**, 184-201

[5] K. Tanabe, (1975). Neumann-type expansion of reflexive generalized inverses of a matrix and the hyper-power iterative method, *Linear Algebra and its Applications*, **10**, 163-175

[6] K. Tanabe, (1975). Statistical regularization of a noisy ill-conditioned system of linear equations by Akaike's information criterion, *Computation and Analysis Seminar*,**6**, 2-25.

[7] K. Tanabe, (1976). Statistical approach to ill-posed problems(in Japanese)A *Mathematical Science*, **153**, 60-63.

[8] K. Tanabe, (1977). The conjugate gradient method for computing the Moore-Penrose inverse and rank of a matrix, *Journal of Optimization Theory and Applications*, **22**, 1-23.

[9] K. Tanabe, (1979). Continuous Newton Raphson method for solving an underdetermined system of nonlinear equations, *Nonlinear Analysis, Theory, Methods & Applications*, **3** , 495-503

[10] K. Tanabe, (1979). Differential geometric methods in nonlinear programming, *Applied nonlinear Analysis*, V. Lakshimikanthan, ed., Academic Press, 709-719

[11] K. Tanabe, (1980). Geometric method in nonlinear programming, *Jour. of Optimization Theory and Applications*, **30** , 181-210

[12] K. Tanabe, (1981). Feasibility-improving gradient-acute-projection methods: A unified approach to nonlinear programming, *Lecture Note in Numerical and Applied Analysis, Vol. 3, The Newton method and related topics*, T. Yamamoto and K. Tanabe, eds., Kinokuniya, 57-76

[13] K. Tanabe, (1983). Numerical behavior of a simultaneous iteration for all the solutions of an algebraic equation, *Information Processing Society of JapanC Numerical Analysis Report*, **4-2**, 1-6.

[14] K. Tanabe, and T. Tanaka,(1983). Fitting curves and surfaces by (nonparametric) Bayes models(in Japanese), *The Earth*, **5** , 179-186

[15] K. Tanabe, (1985). Global analysis of continuous analogues of the Levenberg-Marquardt and the Newton-Raphson methods for solving nonlinear equation, *Annals of the Institute of Statistical Mathematics*, **37**,189-203.

[16] Y. Hiragi, H. Urakawa and K. Tanabe, (1985). Statistical procedure for deconvoluting experimental data. *Journal of Applied Physics*, **58**, 5-11

[17] K. Tanabe, (1987). Complementarity-enforcing centered Newton method for mathematical programming: Global methods, *Cooperative Research Report 5, New method for linear programming*, Institute of Statistical Mathematics, 118-144

[18] H. Kobayashi, T. Abe, T. Kawashiro, K. Tanabe, and T. Yokoyama, (1987). Estimation of the distribution profile of airway resistance in the lungs, *Computers and Biomedical Research*, **20** , 507-525

[19] K. Tanabe, (1987). Centered Newton method for mathematical programming, *System Modelling and Optimization*, M. Iri and K.Yajima, eds., Springer-Verlag, 197-206

[20] H. Inoue, Y. Fukao, K. Tanabe and Y. Ogata, (1990). Whole mantle P-wave travel time tomography, *Physics of the Earth and Planetary Interiors*, **59**, 294-328

[21] K. Tanabe, (1990), Differential geometry of optimization, *Oyousuuri, soukanjyunnbigou*, **3**, 39-50

[22] T. Kawashiro, F. Yamasawa, Y. Okada, H. Kobayashi, and K. Tanabe, (1991). Uneven distribution of ventilation-perfusion ratios in lungs estimated by a modified Newton method, *Mathematical Programming*, **52**, 1-9

[23] K. Tanabe and M. Sagae, (1992). An exact Cholesky decomposition and the generalized inverse of the variance-covariance matrix of the multinomial distribution, with applications, *Jour. of Royal Statistical Society B*, **54**, 211-219

[24] K. Tanabe and M. Sagae, Pivoting strategy for rank one modification of LDM^t-like factorization, *Numerical Algorithms*, **2** (1992), 137-154

[25] M. Sagae and K. Tanabe, (1994). Upper and lower bounds for the arithmetic-geometric-harmonic means of positive definite matrices, *Linear and Multilinear Algebra*, **37**, 279-282 (Tanabe, K. and Sagae, M.)

[26] K. Tanabe, (1996) . Centered Newton method and differential geometry of optimization, *The Institute of Statistical Mathematics, Cooperative research report*, **89**

[27] K. Tanabe, (1998). Bayesian handling of prior information in inverse problems(in Japanese), *Measurement and Control*, **36** , 468-471

Sumiyo UEDA

— Keywords

Pseudo-random numbers, m-sequence, random walk, sojourn time, last visit time

— Research

We showed that m-sequences with characteristic primitive trinomial have evident statistical biases in sojourn time tests.

— Plan

We try to prepare a program package for many kinds of specific tests for randomness which include sojourn time test and last visit time test, etc., and also a program package for several kinds of uniform random number generators which include "Mersenne Twister" by M. Matsumoto, et al., and random number generators with other kinds of distributions.

Satoshi Yamashita

— Keywords

decision making process, financial risk analysis, traffic control, traffic demand prediction, risk control, disaggregated choice model, capital regulation in banking

— Research

- **Financial risk control and risk estimation**
  I have been interested in the estimation of financial risks, which is most required by financial engineers and our government. Most of the works mentioned here are the results of

cooperative research projects with Yasuda Trust & Banking Co.Ltd., Finance Information System Center and the Ministry of finance. We proposed a method for controlling financial markets risk caused by the volatility of stock prices, currency rates and interest rates. We focused on the immunization strategy for bond market (Yamashita, 1995), asset liability management of pension fund (Yamashita and Yato 1996, Yato and Yamashita 1998), risk estimation for BIS regulations (Hagiyama and Yamashita 1998). Markov Decision Process, ARMA model, Pension Actual calculation, Option pricing model and other statistical methods are used to analyze market data in these researches.

- **Traffic control and prediction**
  Road traffic congestion has been quite severe in Japan. In order to improve this situation, traffic volume prediction methods and drivers' behavior models may be helpful to institutions in charge of land development planning, such as the Ministry of Construction and the local governments. Two approaches are considered here. One is to improve drivers' utility function (Yamashita and Kuroda 1996, Yamashita 1997, Yamashita 1997) for goodness of fit of drivers' behavior. The other is to apply statistical time series models to traffic volume prediction.(Uchida and Yamashita 1997).

— Plan

We plan to continue most of the above-mentioned research projects. In particular, the risk estimation in financial markets is very important for the Japanese government in the supervision of banks under the BIS regulations. Our next step will be to develop methods to evaluate the banks' risk affected by financial market volatility. Within a couple of years, we plan to investigate and analyze the effects of the methods using market quote data.

For traffic control and prediction, we will try to combine some behavior metrics models and time series models with existing traffic models. We have already confirmed that Learning Process Model, Latent Valuable Model, Covariance Structure Analysis and other models are effective in improving the prediction power of traffic models. However, we do not have enough case studies yet to put these models into practical use. Two tasks are considered for the future. First, we will continue to investigate other statistical methods that can improve traffic models. Second, we will develop case studies of the above-mentioned methods.

— References

Yamashita S., Yato T. (1998) The sensitivity analysis ALM(asset liability management) of pension fund(in Japanese), Journal of the Japan Society for Simulation Technology, vol.17, No.4, pp21–28

Yamashita S.(1997), The shape of travelers' utility function in estimating the travel demand, Proceedings of the Institute of Statistical Mathematics, Vol.45 No.1, pp89-106

Yamashita S., Hagiyama M.(1997), Subjective distribution of travel time to estimate traffic demand(in Japanese), The Japanese Journal of Behaviormetrics, vol.24, no.2, pp147-106,

Uchida T., Yamashita S.(1997), Vector ARMA Time Series Model for Short-Term Prediction of Traffic Demand, Journal of the Eastern Asia Society for Transportation Studies, Vol.2, No.4, pp1247-1262

Yamashita S., Kuroda K.(1997), Airport Access Behavior of Travelers under Risk of Delay, Journal of the Eastern Asia Society for Transportation Studies, Vol.2,No.1, pp193-205

Hagiyama M., Yamashita S. (1998), A Study of Internal Model to Measure Value at Risk on BIS Regulation, ISM Research Memorandum No. 662 .

Yato T. , Yamashita S. (1995), An Infinite Period Problem of Pension ALM: An Application for MDP, ISM Research Memorandum No. 557.

Yamashita S. (1995), Simulation System and Analysis for Estimating the Effects of Immunization Timing, Technical Report of Kumamoto University, vol. 41-2, pp 181-190

Daluwatte S., Yamasita S., Ando A.(1993), A Historical Fact-finding Study on Transportation and Spatial Abblomeration in Japan: 1884-1985, Memoirs of the Faculty of Engineering Kumamoto University, vol. 38, No. 2.

Yamasita S. , Kuroda K. (1996), Uncertainty evaluation and delay avoidance in mode choice, Journal of Infrastructure Management and Planning, 536-W-31, pp 59-68

3. Research Collaboration

This section describes the research collaboration carried out by the member of the COE-TSA. The ISM has a long history, of which origin is traced back to its initiation in 1985, to promote collaborative research activities in related fields. We would like to explain the principle by borrowing the description appearing in the activity report of the ISM in 1995–1996.

> *Since the very beginning of the history of the Institute, one of the basic principles has been to attach a great importance to applications. The principle came from appreciating that innovative methodologies and theories of statistics are frequently developed in the effort to solve real problems.*

This principle has yielded the successful applications of time series analysis and control in various fields of which some examples appears as a publication of the book

The Practice of Time Series Analysis edited by Akaike and Kitagawa (1999)

which we sent to you prior to your visit at the ISM.

Here a part of the research collaborations conducted by the members of the ISM-TSA is summarized. Some research collaborations are in part supported by the grant of the COE project. Each description for explaining the research collaboration is *voluntarily* given by the member who is in charge of taking care of it. Therefore it should be remarked that this section does not cover all of contributions made by collaborations with the researchers in other fields.

These collaborations are classified in the eight categories: Earth Science, Space Science, Engineering, Economics, Finance, Biology, Medical Science, and Theory and Methods. Each explanation contains the following items:

- **Theme** (Name of cooperative researchers)
  - *Used analysis methods*
  - Discovery and Contribution in Science or Applied Area (Domain)

——*Earth Science*——

- **Analysis of groundwater level data and array data** (G. Kitagawa with Geological Survey of Japan, Dr. Matsumoto, et al.)
  - *Structural time series model, state space model, Kalman filter/smoother, Gaussian-sum filter/smoother*
  - Developed a method of extracting coseismic effects from ground water level data. Detected relation between magnitude-distance vs. coseismic effect. Also discovered increase of water level at a constant rate except for the sudden drops due to earthquakes.

- **Inference on Radon concentration in the underground water** (T. Higuchi with G. Igarashi et al. (University of Tokyo))

- *Continuous stochastic differential equation, State space model, Kalman filter, MLE*
- The method has been designed to detect changes in the underground water radon concentration related to an earthquake. We were able to estimate the original radon concentration in ground water before it was introduced into the radon-detection chamber. The estimation of parameters involved in the model based on the maximum likelihood method gave us a chance to evaluate the exchange constant of radon through the interface (eg., between the gas and liquid phases). This new method is useful to examine time-dependent patterns of changes in groundwater radon and will provide important information about the mechanism of radon changes related to the earthquakes.

- **Precision estimation of arrival time of seismic wave, Extraction of small signal from noisy data, Estimation of changing spectrum, Analysis of array data** (G. Kitagawa with Research Center for Seismology and Volcanology, Prof. Takanami, et al.)
  - *Locally stationary AR model, Householder transformation, state space model*
  - Developed an automatic procedure of estimating the epicenters of earthquakes. Developed a model and estimation method of time varying AR model.

- **On spatial transformation for a correction of earthquake location determined by a small seismic array system** (Y. Ogata with A. Kobayashi, N. Mikami (Japan Meteorological Agency), and Y. Murata (Geological Survey of Japan))
  - *An objective trade-off of penalized sum of squares, the bias compensation using smooth B-spline surfaces with very large number of coefficients*
  - An array of regularly spaced several seismic stations can estimate the location of a distant earthquake using arrival times at the various stations of seismic waves generated by the earthquakes. However, the accuracy decreases as the distance to the epicenter of the earthquake from the array increases. This paper is concerned with the modification of the estimated location by removing its bias which is locally systematic but globally complex, reflecting the structure of the earth. Spline surfaces are used to model such biases. Then a Bayesian procedure is carried out not only to tune the smoothness constraints but also to select the best combination among various sums of squares of differently weighted residuals and various roughness penalties for the smoothing. Using the estimated splines of the posterior mode, the newly determined epicenter locations are transformed to confirm its practical utility. Residual distributions show that our procedure improves the modification by the conventional procedure. A spatial pattern of the residuals reveals some geophysical characteristics.

- **Parameteric approach to the data analysis of point processes** (T. Ozaki: with D. Vere-Jones (Victoria University of Wellington))
  - *Maximum Likelihood Method of Periodic Poisson Process Models and Self-Exciting Point Process Models for earthquake data etc.*
  - Analysis of Kawasumi data with Discussion of the 69 years periodicity of big earthquakes in South Kanto Area.

- **Phase plane model** (M. Ishiguro)
  - *Kalman filter*
  - This model is developed to adjust radio telescope data for stochastic delay (or, phase shift) caused by the inhomogeneity of water vapor density on ray paths to a set of parabolas. A simple quasi dynamical model of floating cloud is developed for the purpose.

- **Space-Time Filtering of meteorological data** (T. Ozaki: with X. Zheng(National Institute of Water and Atmospheric Science, New Zealand) and Japanese Meteorologists in Japan Meteorological Agency)
  - *Application of Local Linearization Filtering method to Data assimilation*
  - Estimation of initial values and error bound of the estimates for the improvement of Numerical Weather Predictions.

——*Space Science*——

- **Separation of spin synchronized signals** (T. Higuchi with G. K. Crawfold, C.T. Russell (UCLA, U.S.A.))
  - *state space model, piece-wise linear spline, automatic outlier detection*
  - In the measurements of electric fields with the Pioneer Venus spacecraft in sunlight, spin synchronized signals often dominates over naturally generated emissions. We present a method to separate natural emissions from the several possible sources of noise. The separation of noises allows us to conduct several scientific studies as to understanding phenomena in planetary physics.

- **Automatic identification of field aligned currents** (T. Higuchi with S. Ohtani (Johns Hopkins University, Applied Physics Lab., U.S.A.)
  - *Linear spline with variable node positions, State space model*
  - We applied the developed procedure to the whole data set of dayside magnetic field measurements (1339 days) made by the DMSP-F7 satellite (sampling time is 1 second). Even such a large task was found to be feasible with the computational capability of standard workstations. This new procedure allowed us to make large statistical studies of various issues about FAC systems.

- **Separation of temporal and spatial effects of ground magnetic field perturbations** (T. Higuchi with P-J, Chi, and C.T. Russell (UCLA, U.S.A.))
  - *Longitudinal data, Multiple-logit transformation, BFGS*
  - Our analysis demonstrates the possibility of inferring the intrinsic magnitude of waves by removing the temporal and spatial dependences and suggests an efficient way to collect a data set from stations in all over the world in order to obtain stable estimates for parameters associated with geophysical phenomena.

- **Fractal analysis of turbulent fluctuations associated with the substorm** (T. Higuchi with S. Ohtani (Johns Hopkins University, Applied Physics Lab., U.S.A.)
  - *Fractal analysis, Cross-spectrum*
  - The result indicates that the microprocess of tail current disruption should be described in terms of turbulent perturbation electric current, and suggests ions should play an important role in a certain instability.

——*Engineering*——

- **Tank modelling of Kiso river and nagara River** (T. Ozaki: with Hydrologist group in Ministry of Construction)
  - *Introduction of Statistical Modelling Method of General Nonlinear Compartment Models. Statistical Estimation of Continuous time Storage Models*
  - Improvement of Riverflow Predictions
- **Analysis and control of ships motion** (Tokyo University of Mercantile Marine, Prof. Ohtsu et. al.)
  - *Multivariate ARX model, Bayesian model, Optimal and/or adaptive control theory, Frequency wavenumber spectrum.*
  - Developed a statistical autopilot system and was already commercialized. Recently developed a Bayesian method of estimating directional spectrum of wave.
- **ExpAR Modelling of Ship Rolling Dynamics** (T. Ozaki: with Oda, and Yamanouchi(Mitsui Ship-Building Co.Ltd.), V. Ozaki(UMIST, now in Sophia University))
  - *Time Series Modelling of General Nonlinear Vibrations, Modelling of Complex Dynamic Systems, Estimation of Nonlinear Stochastic Differential Equation Models for Nonlinear Vibrations.*
  - Improvement of Predictions and Statistical Explanation of Nonlinear Dynamics of Ship Rolling
- **Design of nonlinear control of fissile power plant** (T. Ozaki: with Y.Toyoda, K.Oda (Bailey Japan), H.Peng (Central South Chinese University and ISM))
  - *Nonlinear Multi-variate AR Modelling of Power Plant, Prediction and Control of Complex Systems*
  - Improvement of Predictions, Improvement of Control Performance
- **Analysis of a Human/2-wheeled-Vehicle system** (Makio Ishiguro with Takio Oya et al. (Meiji University))
  - *ARdock*

– For bicycles or motorcycles that are running straight, the following conditions should be satisfied. (1) Balancing stability should be retained. (2) Directional stability (route retention) should be retained. Why can a 2-wheeled vehicle run without capsizing? This has long been a problem stimulating people's keen interest. In the process of finding an answer to the question, we get the idea of ARdock. ARdock is a statistical software developed for fitting multivariate AR model to time series and extracting the information stored in the form of coefficient matrices and the variance covariance matrix. By virtue of the linearity of AR model, which allows the use of the principle of superposition, we can obtain sufficient quantitative knowledge about the system from finite number of experiments, or simulations.

——*Economics*——

- **Time Series Analysis of Economic Growth** (Makio Ishiguro with Minoru Hayashida (Kita-kyusyuu Univ.))
  - *MARTS model*
  - This research has just started. The aim of the project is to focus on the very low frequency component of economic time series data. We are interested in finding a statistic model which bridges the economic growth theory and data analysis.
- **Dynamic macroeconomic Modelling** (T. Ozaki: with V. Ozaki (Sophia University))
  - *Introduction of Dynamical System for the Hicksian IS-LM paradigm, Nonlinear & Non-stationary State Space Modelling of Output & Interest Rate Dynamics.*
  - Explanation, Prediction and Simulation of Dynamics of Demand and Supply
- **Dynamic X11 model** (T. Ozaki: with P. J. Thomson (Victoria University of Wellington))
  - *Model-Based (State Space Models) Approach for the X11 type Seasonal Adjustment, Introduction of Nonlinear Filtering Method of the Nonlinear State Space Model for Multiplicative Nonlinear Seasonal Time Series.*
  - N/A
- **Seasonal adjustment method by using state space model** (S. Sato)
  - *Decomp*
  - X11 or X12-ARIMA are widely used in Japan. But there are few people having an advance knowledge for a seasonal adjustment in the Japanese statistical offices. We think that more automatic methods are suitable for Japanese officers than X-11 or X12-ARIMA. We proposed the method by using state space model and AIC. In this method, the people in practice does not need to select the many options like X11 or X12-ARIMA. "Decomp" method is one of theses methods. In this research, we consider the problems caused in practical use of "Decomp".And also we develop the software which is easy to use for everyone.

- **Simulating Monetary Policy by Statistical Control Method** (G. Kitagawa with Y. Kawasaki, S. Sato (ISM) and N. Tanaka (21st Century Public Policy Institute))
  - *Multivariate autoregressive model, statistical control, robust year-on-year change*
  - Based on a multivariate autoregressive model, we simulate various monetary policies and measure the effects of them by the statistical control method. At first we introduce a new method to transform the data stationary. Based on the estimated model, the growth rate of monetary base is set to various different rates to see how it influences other variables, especially real sector variables like production index or machinery orders. Moreover reported are optimal control inputs to achieve desirable recovery of real sector, or to raise inflation rate which is argued within a context of managed inflation policy.

——*Finance*——

- **Estimation of stochastic differential equation models for financial time series** (T.Ozaki: with I.Shoji(Sumitomo Life Insurance Co.Ltd., now in Tsukuba University))
  - *stochastic differential equation models*
  - Characterization of volatility of financial data, Improvement of prediction performance of theoretically introduced stochastic differential equation models for interest rate dynamics.

- **Jump-Diffusion model fitting for financial data** (T.Ozaki: with M.Iino (The Yasuda Trust and Banking Co.Ltd))
  - *Characterization of Non-Gaussian financial time series, Improvement of prediction performance.*
  - N/A

- **Pair investment strategy via cointegration tests** (Y. Kawasaki with S. Tachiki (The Nikko Securities, Co. Ltd.))
  - *Cointegration test, Johansen's LR test, portmanteau tests*
  - Cointegrated stock prices are sought by the FIML method among the stocks in Tokyo stock exchange price index. Long/short investment strategies are designed based on the estimated cointegration vectors. In the method we propose, the investments are not always risk-neutral, but a little bit biased on the short position. We also performed the tests of the linear restriction that the cointegration vector is (1,-1), which justifies the risk neutral investment. One of the most important findings in this research is that the number of such pairs are much less than the actual pairs maintained by the institutional investors.

- **Smoothness prior approach to estimate large scale multifactor models** (Y. Kawasaki with S. Sato (ISM) and S. Tachiki (The Nikko Securities, Co. Ltd.))

- *Kalman filter, MLE, multifactor models*
- For the most of institutional investors, multifactor models are the tools to predict the stock returns in the next month (,say). The most common way is to estimate cross-sectional regression model followed by the ad hoc smoothing like exponential smoothing or moving averages. Here we proposed a state-space modeling of the multifactor, which enables us to determine the degree of the smoothness of factor payoffs from the data, using the method of maximum likelihood. It turned out that the simple introduction of Kalman filter is almost equivalent to the OLS based payoffs without smoothing, which lead to the new modeling called 'the temporal effect model'. The main finding is that the modeling cross-sectional correlations of observational equation is the most important to extract the smooth payoffs from the noisy series.

- **On the effects of scheduled announcements on foreign exchange markets** (Y. Kawasaki with M. Susai (Nagasaki University) and Y. Kuwana (Hitotsubashi University))
  - *Time series regression, testing dummy variables*
  - The tick by tick foreign exchange rate between US dollar and Japanese yen is analyzed. We focus on the effect of scheduled announcements which are done regularly by the governmental authorities. We performed the tests on the persistency of such effects on the changes of yen/dollar rate and on the number of quotes in a fixed interval. Our conclusion is that, the announcement effects of price index are usually insignificant, whereas the effects of other official statistic like Industrial Production and Trade Deficit are significant in general.

——*Biology*——

- **Folding and Inverse Folding of Lattice Proteins** (Y.Iba with G.Chikenji, M.Kikuchi, and K.Tokita (Osaka Univ.))
  - *Markov Chain Monte Carlo, Multi-Self-Overlap Ensemble*
  - The method is applied to the study of thermodynamic properties of lattice heteropolymers at low temperature. We also developed a method of design of polymers that fold into a desired shape, which is successfully used with the Monte Carlo algorithm.

——*Medical Science*——

- **Analysis of Clinical Longitudinal Data** (M.Ishiguro with A.Yafune (Kitasato Institute))
  - *AIC, Bayes, Bootstrap, Kullback-Leibler Information, Monte Carlo, Nonlinear Mixed Effects Model*

- In this study, we analyze clinical longitudinal data whose profiles can be described by nonlinear models. The inter-individual variations of the profiles are incorporated as the population distributions of parameters specifying the models. Combined with Bayesian approaches, this population approach makes it possible to estimate the whole profile for a subject based on quite a few or even a single observation from the subject. It also makes it possible to select the optimum measurement point(s) for estimating the whole profile. Such approaches are hence quite informative from clinical viewpoints.

- **Dynamics control of breathing during exercise and hypercapnia** (Y. Tamura with Y. Oku et al. (Kyoto University))
  - *Multivariate AR model, Yule-Walker method*
  - The dynamic influences of end-tidal CO_2 and exercise on ventilation are compared when CO_2 and exercise are imposed separately and when they are imposed simultaneously. The results show that the dynamics of the response to CO_2 inhalation, exercise and their combination are nonlinear and that the combination of CO_2 inhalation and exercise magnifies the nonlinear behavior. Ventilation is largely unaffected by either work rate or end-tidal CO_2 at 1 cycle min^{-1}. During simultaneous CO_2 and work rate forcing, ventilation tends to follow the change in the end-tidal CO_2.

- **Evaluation of cancer prevention strategies by computerized simulation model: an approach to lung cancer** (Y. Tamura with N. Yamaguchi et al. (National Cancer Center Research Institute))
  - *Markov stochastic process, Computer simulation*
  - A computerized simulation model was developed to evaluate the potential impact of primary and secondary prevention on lung cancer mortality in Japan. The simulation shows that the number of lung cancer deaths can be reduced either by smoking cessation or screening programs, and that the reduction is proportion to the increase in the annual smoking-cessation rate and to the anual increment in the screening rate.

- **Nonlinear time series modelling of heart beat(ECG) data** (T. Ozaki: with T. Wada (Inagi Municipal Hospital))
  - *Non-parametric AR Modelling, Semiparametric(RBF) AR Modelling*
  - Characterization of nonlinear dynamics of ECG data, Prediction, and Simulation

- **Nonlinear time series modelling of EEG data** (T. Ozaki: with P. Valdes, J. C. Jimenez, R. Biscay (Cuban Neuroscience Center), Z.Shi(East South University of China and ISM) etc.)
  - *Maximum Likelihood Estimation of Neural Mass Model, Parametric nonlinear AR Modelling of Epilepsy Data, Non-parametric AR Modelling, Semi-parametric(RBF) AR Modelling*
  - N/A

——*Theory and Method*——

- **Locally Stationary AR Modelling** (T. Ozaki: with Howell Tong (UMIST, now in University of Kent))
  - *Semi-automatic spectral estimation of non-stationary time series*
  - Detection of arrival time of seismic waves. Change point detection of time series

- **Asymmetry in economic time series and SSAR model** (S. Sato with N. Kunitomo (Univ. of Tokyo))
  - *Asymmetry, Nonlinear time series, MLE*
  - One important characteristic of many economic time series, which has been often ignored, is the asymmetrical movement between the downward phase and the upward phase in their sample paths. Since this feature cannot be described by the standard autoregressive moving average (ARMA) models, we introduce a new class of the simultaneous switching autoregressive (SSAR) model, which is a non-linear Markovian switching time series model. We consider the theoretical properties and the parameter estimation of this model. We also apply this to the financial market data.

- **Time series analysis based on state space model and smoothness priors** (G. Kitagawa with University of Hawaii, Prof. Will Gersch)
  - *General state space model, Kalman filter, non-Gaussian filter*
  - Developed various nonstationary time series models and their fitting methods. They are collected in a monograph.

- **Generalized information criterion** (G. Kitagawa with Kyushu University, Prof. Konishi)
  - *Functional statistics*
  - Developed new information criterion GIC which can be applied wider class of models and more precise bias correction than AIC and TIC.

- **Application of the Bootstrap method to PCA** (T. Higuchi and H. Kawano (Kyushu Univ.))
  - *Bootstrap, Principal component analysis, Smoothing*
  - The PCA is frequently used in particular situations where we would like to determine a normal directions of discontinuities and wave normal directions. In such case, we are interested in how precisely we can estimate the minimum axis direction in a framework of the PCA. We employ the concept of the Bootstrap method for evaluating it. The cases of dependent data, i.e., data with a long-term trend component, are also considered in the proposed scheme.

4. Supplement

4.1. List of Books

Statistics via Information Criterion (in Japanese), Kyoritsu Pub. Co., (1983) p 236 (Y. Sakamoto and M. Ishiguro, G. Kitagawa)

Akaike Information Criterion Statistics. D.Reidel Publishing Company, (1986) (Y.Sakamoto and M.Ishiguro and G. Kitagawa)

FORTRAN 77 Programming for Time Series Analysis, Iwanami Pub. Co. (1993)

Practice of Time Series Analysis I and II (in Japanese), eds., H. Akaike and G. Kitagawa, Asakura Pub. Co. (1994 and 1995)

A Method of Modern Time Series Analysis and Computer Programming, (Chinese translation of 6), Translated by Q.-X. Jiang et al., Tarian University Press (1996)

Smoothness Priors Analysis of Time Series, Lecture Notes in Statistics, No. 116, Springer-Verlag (1996) (G. Kitagawa and W. Gersch)

Selected Papers of Hirotugu Akaike, Springer Series in Statistics, Springer-Verlag (1997) (eds., E. Parzen, K. Tanabe and G. Kitagawa)

The Method of Time Series Analysis (in Japanese), Asakura Pub Co. (1998)

The Practice of Time Series Analysis (English translation of 4)

4.2. List of Software Products

We give a partial list of the softwares developed by the members. There are other descriptions concerning to the softwares developed in the Institute. Please visit

`http://www.ism.ac.jp/english/acrep/acrep8.html`

In addition, there is a useful WWW service in ISM

`http://www.ism.ac.jp/cdsc/ismlib/ismlib.e.html`

to provide users with the softwares and other resources, which is called the ISMLIB. The purpose of the ISMLIB is as follows (from WWW for ISMLIB):

a. To distribute software and data as products of the research activity of the Institute of Statistical Mathematics to the society

b. To raise the activity of statistical science, and trigger new researches

c. To make our Institutes achievements be properly evaluated

4.2.1. Software

TIMSAC-72 A Time Series Analysis and Control Program Package (1971) (with H. Akaike) and in statistical Analysis and Control of Dynamic Systems by H. Akaike and T. Nakagawa (1988) Kluwer Academic Publishers

TIMSAC-74 A Time Series Analysis and Control Program Package - (1) Computer Science Monographs, No.5 (H. Akaike, E. Arahata and T. Ozaki) (Mar. 1975) 2nd Ed. (Mar. 1989) A Time Series Analysis and Control Program Package - (2) Computer Science Monographs, No.6 (H. Akaike, E. Arahata and T. Ozaki) (Feb. 1976) 2nd Ed. (Mar. 1989)

TIMSAC-78 Computer Science Monographs, No. 11, The Institute of Statistical Mathematics (1979) (H. Akaike, G. Kitagawa, E. Arahata and F. Tada)

This program package provides programs for fitting AR, VAR and locally stationary autoregressive models. The main feature of the package is the unified use of the Householder transformation which presumably has not been used time series analysis before. It also contains programs for fitting AR and ARMA models by the maximum likelihood method.

GALTHY A Probability Density Estimator Computer Science Monographs, No.9 (H. Akaike and E. Arahata,1978)

OUTLAP An outlier analysis program. Computer Science Monographs, No. 15, The Institute of Statistical Mathematics (G.Kitagawa,1980)

A program for Bayesian detection and correction of outlying observations based on the method published in Kitagawa-Akaike (AISM 1982).

TIMSAC-84 Part I and II Computer Science Monographs, The Institute of Statistical Mathematics, Tokyo No.22 and No.23 (H. Akaike, G. Kitagawa, T. Ozaki, M. Ishiguro, Y. Ogata, Y. Tamura, E. Arahata, K. Katsura and Y. Tamura,1985)

This package contains various programs for nonstationary or nonlinear time series analysis. I made program DECOMP and TVCAR. DECOMP is a software for seasonal adjustment by state space modeling. Actually, it can be used for structural decomposition problems in various fields ([8], [14]). TVCAR is the program for fitting time-varying AR model and estimation of changing spectrum ([11], [16]).

A Program Package for Drawing Graphs with an X-Y plotter Computer Science Monographs, No.18 (E. Arahata) (Mar. 1985)

FORTRAN 77 Time Series Analysis Programs Iwanami Publishing Company (1993)

This program package contains various programs for time series analysis from fundamental ones to non-Gaussian state space modeling. Recently, Web version of the programs were developed by the Geological Survey of Japan.

PC Program Package: Statistical Analysis of Seismicity (SASeis) (Utsu and Ogata, 1997)

The computer programs of point-process models including estimation of the modified Omori function, the ETAS model and the related residual analysis and simulation of the data, were included in the Software Library for personal computers published by the

International Association of Seismology and Physics of Earth's Interior (IASPEI) in collaboration with the Seismological Society of America.

Softwares developed by M. Ishiguro

There are many softwares developed by M. Ishiguro. Please visit
`http://www.ism.ac.jp/cdsc/ismlib/soft.e.html`

4.2.2. Service through WWW

Web Decomp Proceedings of the Institute of Statistical Mathematics, Vol.45, No.2, 233–243, (Sato, 1998)

This system, which is based on DECOMP and TIMSAC, allows the users to analyze their own data and to perform a seasonal adjustment without installing any softwares. An important feature of Web-DECOMP system is that it is a WWW site of the Internet and most of the computation can be done by server machine, not by user's computers.

WWW Service of Statistical Seismicity Analysis (Ogata)

Collaborating with Earthquake Research Institute, University of Tokyo, we are offering Web service for public in selecting data of interest from earthquake catalogues in local, Japan and world and analyzing them through point process models including applications of the modified Omori Poisson process and the ETAS model and relevant graphical analyses. This service will be particularly important in applying them to the current seismicity in almost real time.

4.3. URL of Homepage

4.3.1. Member's Home page

Please visit each homepage of which URL is presented in **1.3.**. Only Prof. G. Kitagawa provides with information on description of what his homepage contains;

- G. Kitagawa `http://www.ism.ac.jp/~kitagawa/`

  My homepage contains

  - Picture, Address
  - Link to the homepage of DECOMP, which contains link to WebDECOMP, PowerPoint presentation of seasonal adjustment method (in Japanese) and Postscript and PDF files of an article.
  - Publications (List of Papers, Books, Research Memos, Softwares, Proceeding papers, Review or expository articles, Invited talks and the information about number of citations.)
  - Link to OpenStat(which is now under construction and currently contains links to WebDecomp and OpenLec. OpenLec now contains 11 PowerPoint presentations on introductory or advanced talks (lecture) on time series and information criterion.

– Link to Prof. Akaike's homepage. (By permission of Hiro, I created his home page.)

4.3.2.

◇ COE HomePage `http://www.ism.ac.jp/~higuchi/COE/`

◇ Web Decomp `http://www.ism.ac.jp/~sato/`

4.4. List of Awards

- Second Japan Statistical Society Prize (G. Kitagawa, 1997)
- Gordon Bell Prize (M. Taiji, 1995)

4.5. Press

- 4.6 "Web Decomp" was reported in the Japanese magazine ("Weekly Economist" in Sep. 2nd, 1997).
- GSJ
- 21st Century