



THE INSTITUTE OF
MANAGEMENT SCIENCES

NEWSLETTER OF THE
TIMS COLLEGE
on
SIMULATION AND GAMING

BRUCE SCHMEISER and LEE SCHRUBEN, CO-EDITORS

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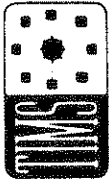
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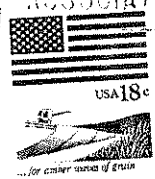
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BALLOT FOR "BEST SIMULATION AND GAMING" PAPER IN *MANAGEMENT SCIENCE*

Six papers have been nominated for the newly established "Best Simulation and Gaming Paper" award, given by the College on Simulation and Gaming, for the paper appearing in *Management Science* which receives the most votes from the members of the college. The papers nominated for volume 26 (1980) are:

Nabil R. Adam and Julius Surkis, "Priority update intervals and anomalies in dynamic ratio type job shop scheduling rules," 1227-1237.

Richard M. Burton and Borge Obel, "The efficiency of the price, budget, and mixed approaches under varying *a priori* information levels for decentralized planning," 401-417.

Norman Gaither, "A stochastic constrained optimization model for determining commercial fishing seasons," 143-154.

Lee W. Schruben, "A coverage function for interval estimators of simulation response," 18-27.

Bernard W. Taylor III and Laurence J. Moore, "R & D project planning with *Q-GERT* network modeling and simulation," 44-59.

Francis D. Tuggle and Donald Gerwin, "An information processing model of organizational perception, strategy and choice," 575-592.

The ballot is for your use as a member of the college. Please vote for one paper only. The ballot should be mailed to Bruce Schmeiser, School of Industrial Engineering, Purdue University, West Lafayette, IN 47907 by September 1, 1981.

The award, which consists of a plaque and \$500, will be given at the business meeting of the College on Simulation and Gaming at the Houston ORSA/TIMS meeting next fall.

1980 "Best Paper in Simulation and Gaming" *Management Science*

Vote for one, only.

- Adam and Surkis, 1227-1237.
- Burton and Obel, 401-417.
- Gaither, 143-154.
- Schruben, 18-27.
- Taylor and Moore, 44-59.
- Tuggle and Gerwin, 575-592.

Any comments supporting your choice would be appreciated.

MAIL TO: Bruce Schmeiser, School of Industrial Engineering, Purdue University, West Lafayette, IN 47907 by September 1, 1981.

NEWSLETTER IDEAS

At the Toronto College meeting the following suggestions were made concerning the Newsletter:

- (1) Have a "Consultants Corner" where persons could ask questions about simulation methodology. Answers could be addressed to the person making the inquiry and published in the next newsletter.
- (2) Have a "Teaching Aids" section where problem sets, exam questions (?), or presentation ideas could be shared.
- (3) Have a "Job Market" section where positions are listed.

We will try these ideas. If you have a contribution send it to:

Lee Schruben
SORIE Upson Hall
Cornell University
Ithaca, NY 14853

COLORADO SPRINGS BUSINESS MEETING

November 10, 1980

Attending: Ray Alberg, Bill Biles, John Carson, Ben Fox, Averill Law, John Ramberg, Bruce Schmeiser, Lee Schruben.

1. Averill called the meeting to order at 5:30 PM.
2. Advancing the 1981 Winter Simulation Conference \$1500.00 was approved.
3. George Fishman has asked to end his term as the College's representative to the Winter Simulation Conference Board of Directors. Averill nominated both Alan Pritsker and Bill Schmidt as the College's new representative. Both were approved. Averill will ask them if they are willing and they will mutually decide on the new representative.
3. The progress of the Simulation Department of *Management Science* was discussed.
4. Bruce Schmeiser asked about the progress of the conference planned by the College which was approved at the 1979 meeting at the 1979 Winter Simulation Conference in San Diego. Those attending agreed that we did not want to sponsor a conference which would further spread our efforts and time among the various existing conferences.
5. Meeting adjourned about 6:15 PM

Bruce Schmeiser
Secretary-Treasurer

TORONTO BUSINESS MEETING

May 5, 1981 at the CORS/TIMS/ORSA Joint Meeting, Toronto.

Attending: John Babu, Bill Biles, David Kelton, Averill Law (Chairman), Bill Maxwell, Tuncer Oren, Robert Sargent, Bruce Schmeiser, Lee Schruben, Dennis Smith

1. Averill called the meeting to order at 5:40 PM.
2. Bruce Schmeiser noted that the college has about \$7600 in the treasury. In addition, the 1981 Winter Simulation Conference has been advanced \$1500. About \$5300 is in a money market fund, with most of the rest in an account at TIMS headquarters.
3. Bruce Schmeiser announced that he was resigning as co-editor of the college newsletter after the spring 1981 issue.
4. There was a discussion of various issues, primarily revolving around the current activities of the college, possible additional activities, obtaining wider visibility, and the problem of not being able to update the college membership list often.
5. The meeting adjourned about 6:15 PM.

Bruce Schmeiser
Secretary-Treasurer

ORLANDO BUSINESS MEETING

December 4, 1980 at the 1980 Winter Simulation Conference, Orlando, FL.

Attending: Gordon Clark, Robert Cooper, Joseph Fasenda, George Fishman, Averill Law, George Mendonsa, Alan Pritsker, Steve Roberts, Robert Sargent, Bruce Schmeiser, Tom Schriber, Lee Schruben, Charles White

1. Averill called the meeting to order at 5:35 PM.
2. The "best paper" award for *Management Science* was discussed. No action was taken. The award is being announced in *Management Science* and the *Newsletter*.
3. George Fishman, the Simulation Department editor for *Management Science*, discussed the department's activities. The number of submissions has increased, but the number of acceptances has not increased. One paper will probably appear in 1981.
4. Alan Pritsker is the new representative to the WSC Board of Directors, replacing George Fishman who has served for the last three years. The College thanks George for his efforts.
5. Alan Pritsker asked for comments regarding the WSC for his guidance. After quite a bit of discussion, a return to the 1979 format was suggested. It was suggested that the College vice president, who coordinates the College's interaction with conference programs, make an effort to work with the WSC just as he has worked with the Joint National ORSA/TIMS meetings in the past.
6. Bruce Schmeiser reported that the College has \$6884.72 on hand, \$2227.23 at TIMS headquarters and \$1500.00 advanced to the 1980 Winter Simulation Conference.

7. Bruce Schmeiser asked that the College approve his writing checks, as required by Lafayette National Bank, where the College's checking account will be maintained. Approved by acclamation.
8. Meeting adjourned about 6:30 PM.

Bruce Schmeiser
Secretary-Treasurer

DAVID KELTON NEW CO-EDITOR OF THE NEWSLETTER

I (BWS) resigned as newsletter editor at the business meeting in Toronto effective after this issue. It has been a pleasure to see the newsletter grow from its beginning in 1976, when Dick Nance was College chairman. David Kelton, Kent State University, is the new co-editor. He and Lee Schruben, who is continuing, have many ideas for additional features and expanded format for the newsletter. I encourage you to send them any ideas, notices, or even mini-articles that you think are appropriate for the newsletter.

ANNOUNCEMENT

A new technical department called *SIMULATION MODELING AND STATISTICAL COMPUTING* has been established in the *Communications of ACM* (circulation 55,000 per issue) with Robert G. Sargent as Department Editor. Research contributions which cover the methodologies associated with both these areas and the interactions between them are to be published under this new department. The scope includes innovative and new modeling techniques and approaches (independent of application); model specification languages and model documentation; simulation languages and packages; statistical languages and packages; efficiency of languages and their components; user interfaces, e.g., graphical and interactive; methodologies and techniques for analyzing simulation output data, and experimental data generally, in particular those utilizing the computer in a new or innovative way, e.g., use of graphical displays; verification and validation; methodologies, techniques, and approaches for performing simulation on new types of computer architectures, e.g., distributed systems; and random number and random variate generators. Those interested in having their research contributions published should forward four copies of their resulting manuscripts for refereeing and review to the department editor:

Robert G. Sargent
Dept. of Industrial Engineering
and Operations Research
Syracuse University
Syracuse, New York 13210
(315) 423-4348

**"SIMULATION USING GPSS"
(An Intensive Five-Day Course)**

An intensive five-day course on "Simulation Using GPSS" will be offered in The University of Michigan's Engineering Summer Conferences July 13-17, 1981. The course consists of lectures from 8:30 a.m. until 4:30 p.m. each day, and hands-on experience with GPSS in computing center workshops which take place from 5 p.m. until 8 p.m. on the first, second, and fourth course days. (Free psychiatric consultations are provided on the evening of the third day.) In addition, about 30 hours of directed private study is required before the course begins. For further information, contact Prof. Thomas J. Schriber, Graduate School of Business, The University of Michigan, Ann Arbor, 48109 (313-764-1398).

1980 WINTER SIMULATION CONFERENCE PROCEEDINGS

Copies of the Proceedings of the 1980 Winter Simulation Conference are still available. Bob Sargent says they may be ordered from the Society for Computer Simulation, P.O. Box 2228, La Jolla, CA 92037.

ABSTRACTS OF RECENT PAPERS

The number of abstracts submitted during the last six months was way down. Therefore we have supplemented the list with some papers which the editors thought interesting. To encourage submissions, forget the form given in the last issue and simply send a copy of the report to either editor. We'll see how that works for six months.

ON THE STATISTICAL CONTROL OF SIMULATION RUN LENGTH, Philip Heidelberger, Peter D. Welch, IBM Thomas J. Watson Research Center, Yorktown Heights, New York 10598, Technical Report RC 8571 (#37365) 11/21/80.

Two central problems in simulation methodology are the generation of confidence intervals for the steady state means of the output sequences and the sequential examination of these confidence intervals to control the run length. This paper addresses these two problems.

HAMMERSLEY'S LAW FOR THE VAN DER CORPUT SEQUENCE: AN INSTANCE OF PROBABILITY THEORY FOR PSEUDORANDOM NUMBERS, A. Del Junco and J. Michael Steele, Ohio State University and Stanford University.

The analogue of Hammersley's theorem on the length of the longest monotonic subsequence of independent, identically, and continuously distributed random variables is obtained for the pseudorandom van der Corput sequence. In this case there is no limit but the precise limits superior and inferior are determined. The constants obtained are closely related to those established in the independent case by Logan and Shepp, and Vershik and Kerov.

A RENEWAL THEORETIC APPROACH TO BIAS REDUCTION IN REGENERATIVE SIMULATIONS, Marc S. Meketon, Xerox Corporation, Xerox Square, Rochester, New York 14644; Philip Heidelberger, IBM Thomas J. Watson Research Center, Yorktown Heights, New York 10598.

The special structure of regenerative processes is exploited to derive a new point estimate with very low bias for steady state quantities of regenerative simulations. If the simulation run length is t units of time, the bias of the new estimate is of order $1/t^2$ as opposed to the bias of order $1/t$ associated with more standard estimates. The bias reduction is achieved by continuing the simulation until the first regeneration after time t and then forming the ratio estimate which involves the random number of regenerative cycles observed during the simulation. Empirical results for several queueing models demonstrate that the bias reduction can be substantial for small values of t .

A PERSPECTIVE AND PROPOSAL FOR THE INITIAL TRANSIENT PROBLEM IN SIMULATION, George S. Fishman, Technical Report 80-6, December 1980, Curriculum in Operations Research and Systems Analysis, University of North Carolina at Chapel Hill.

This paper presents a perspective on the initial transient problem in steady-state simulation. In particular, it enumerates five generally accepted facts: 1) Conditions prevailing at the beginning of a simulation influence sample paths. 2) The extent of influence is a function of the strength of autocorrelation. 3) Some initial conditions are less detrimental than others are. 4) Truncation reduces bias but usually increases variance. 5) So far no complete solution exists. The remainder of the paper describes a proposal for solving the problem. It relies on the relatively weak assumption that the conditional means in a stochastic process of interest are related linearly. An estimator of the steady-state mean is described which has considerably less bias than one can achieve via conventional truncation. An interval estimator is also described which follows from standard regression theory. A test for residual bias is presented which enables a user to judge whether or not sample data meet the minimal requirements for the proposed technique to apply. A second test allows a user to judge whether or not a more efficient estimation technique can be used.

A PERSPECTIVE ON THE INITIAL TRANSIENT PROBLEM IN STEADY-STATE SIMULATION, W. David Kelton, Technical Report WS-8101, Department of Administrative Sciences, Kent State University, January 1981.

AN ANALYTICAL EVALUATION OF ALTERNATIVE STRATEGIES IN STEADY-STATE SIMULATION, W. David Kelton, Department of Administrative Sciences, Graduate School of Management, Kent State University; Averill M. Law, Department of Industrial Engineering, University of Wisconsin-Madison.

We consider the simple technique of making independent and probabilistically identical simulation replications to estimate the steady-state mean of a stochastic process. Under a fixed-total-budget constraint, the effects of choice of the number of replications and of initial deletion amounts on several different measures of point estimator and confidence interval quality are analytically investigated using a nonstationary first-order autoregressive model. General recommendations on the choice of replications and deletion are made. In particular, we conclude that deletion of some amount of the initial output in a replication can be an effective and efficient method of dealing with initialization bias; this conclusion differs from several previous studies on the efficacy of deletion.

A PERSPECTIVE ON THE USE OF CONTROL VARIABLES TO INCREASE THE EFFICIENCY OF MONTE CARLO SIMULATIONS, S. S. Lavenberg, and P. D. Welch, Management Science, Vol. 27, No. 3, March 1981.

This is a survey paper on the application of control variables to increase the efficiency of discrete event simulations. The emphasis is on the practical problems and potential of applying the method in the simulation of complex systems. The basic theory of control variables is reviewed and the equivalence of control variables and multiple estimators is discussed. Techniques for generating control variables are described. Inefficiencies resulting from the statistical estimation of control variable coefficients and the problem of confidence interval generation are treated. This is done both within the context of the method of independent replications and the regenerative method. The application literature is reviewed and the conditions under which control variables could be profitably applied in practical simulations are described. Finally, there is a set of recommended directions for future research.

RELATIVE WIDTH SEQUENTIAL CONFIDENCE INTERVALS FOR THE MEAN, Averill M. Law, W. David Kelton, and Lloyd W. Koenig, Commun. Statist. - Simula. Computa., B10(1), 29-39 (1981).

In this paper we discuss two sequential procedures for constructing confidence intervals for the mean with a relative width requirement. Carefully stating the procedure proposed by Nadas and the procedure considered by Thomas, Iglehart, Robinson, Lavenberg and Sauer, and Law, we give some efficiency and consistency results concerning the latter, and compare their small-sample performances on a variety of stochastic models for which analytic results are available.

FORMULAS FOR THE VARIANCE OF THE SAMPLE MEAN IN FINITE STATE MARKOV PROCESSES, Gordon B. Hazen and A. Alan B. Pritsker, J. Statis. Comput. Simul. 1980, Vol. 12 pp. 25-40.

Formulas are derived for the variance of sample means associated with finite state Markov processes. Numerical results are presented to illustrate the use of the formulas for example processes. The formulas can be used to evaluate proposed statistical methods for estimating the variance of a sample mean obtained from simulation experiments.

USING SIMULATION IN CARDIOVASCULAR DISEASE CONTROL, A. Ravindran, S. Sadagopan, Clifford C. Petersen, Lt. Col. Charles P. Hatsell, M.D., Purdue University, Industrial Engineering, Grissom Hall; Professor A. Ravindran, West Lafayette, Indiana 47907.

The United States Air force is planning a comprehensive program to reduce the incidence of cardiovascular disease among Air Force personnel. The program will use a risk profile based on the Framingham study to identify high-risk personnel for selective treatment. A risk-reduction program will then provide medication and education for those selected for therapy. To assist the Air Force in designing a cost-effective risk-reduction program, we developed a comprehensive computer simulation model called P-HEART (Purdue Heart Evaluation and Risk Tabulation). P-HEART simulates the USAF population and the processes of identifying high-risk individuals and selecting appropriate therapies for them. It also calculates the costs and benefits of the cardiovascular disease control program for different risk-reduction policies. This paper describes the simulation model, its validation, and its results.

A METHODOLOGY FOR VALIDATING MULTIVARIATE RESPONSE SIMULATION MODELS BY USING SIMULTANEOUS CONFIDENCE INTERVALS, Osman Balci and Robert G. Sargent, Department of Industrial Engineering and Operations Research, Syracuse University, Syracuse, New York 13210.

A methodology is presented to test the validity of a multi-variate response simulation model, under a given experimental frame for an acceptable range of accuracy, by using simultaneous confidence intervals. The methodology contains a trade-off analysis among cost of data collection, sample sizes of observations, estimation error, and the probability of absolute value of error in estimation.

ACCELERATED ACCURACY IN THE SIMULATION OF MARKOV CHAINS, George S. Fishman, Technical Report 81-1, January 1981, Curriculum in Operations Research and Systems Analysis, University of North Carolina at Chapel Hill.

This paper describes a method of obtaining results from the simulation of a finite state positive recurrent aperiodic Markov chain at a cost considerably below the cost required to achieve the same accuracy with pure random sampling. By reorganizing k independent epochs or tours simulated serially into k replications simulated in parallel, one can induce selected joint distributions across replications that produce the cost-saving benefits. The joint distributions follow from the use of rotation sampling, a special case of the antithetic variate method.

For a finite state nearest neighbor chain the paper shows that even for independent parallel replications the cost of achieving a specified accuracy with serial simulation relative to the cost for parallel simulation has a lower bound $O(k^{1/2})$ as $k \rightarrow \infty$. When rotation sampling is used this bound is $O(k^2/(1+nk)^3)$. This lower bound also holds for the more general finite state chain. A simulation of the M/M/1 queueing model with finite capacity n is used to illustrate the effectiveness of the technique for selected values of k, n and activity level ρ .

ANALYSIS OF SIMULATION EVENT INCIDENCE GRAPHS, Lee Schruben, School of Operations Research and Industrial Engineering, College of Engineering, Cornell University, Ithaca, New York.

The event incidence graph presented here can be used to develop alternative event oriented representations of a system. Several candidate model structures can be considered for possible implementation as discrete event simulation programs using an event-scheduling approach. Applications of basic graph analysis techniques are illustrated in the context of a simple example.

In addition, the following articles appeared in the April 1981 issue of the *Communications of the ACM*, which was a special issue on Simulation Modeling and Statistical Computing, edited by Nabil Adam.

The Time and State Relationships in Simulation Modeling

Richard E. Nance

Concepts and Criteria to Assess Acceptability of Simulation Studies: A Frame of Reference

Tuncer I. Oren

A Methodology for Cost-Risk Analysis in the Statistical Validation of Simulation Models

Osman Balci and Robert G. Sargent

Asynchronous Distributed Simulation via a Sequence of Parallel Computations

K. M. Chandy and J. Misra

Use of Polya Distributions in Approximate Solutions to Nonstationary M/M/s Queues

Gordon M. Clark

A Conceptual Framework for Research in the Analysis of Simulation Output

Thomas J. Schriber and Richard W. Andrews

A Spectral Method for Confidence Interval Generation and Run Length Control in Simulations

Phillip Heidelberger and Peter D. Welch

Control of Initialization Bias in Multivariate Simulation Response

Lee W. Schruben

Minimum Mean-Squared-Error Estimators for Simulation Experiments

James H. Donnelly and Robert E. Shannon

Regression-Adjusted Estimates for Regenerative Simulations, with Graphics

P. Heidelberger and P.A.W. Lewis

