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THE INSTITUTE OF MANAGEMENT SCIENCES

NEWSLETTER

President's Message

This issue of the *Newsletter* contains several items indicating the continuing leadership role the College plays in the simulation world.

Editor Jim Swain has taken it upon himself to begin what we all hope will be a regular column, giving views (spiced perhaps with some opinion) on the minimally acceptable level of effort in statistical design and analysis of simulation experiments. Jim has also taken the opportunity to reflect on the role of AI in simulation; AI has of course attracted notable attention with regard to its use in MS/OR generally, especially since the column written recently on the subject by TIMS President Thomas Cook in *OR/MS Today*.

Past College President Bruce Schmeiser has also written a provocative piece appearing here involving some random questions on randomness as well as on several other issues of broad concern to simulation practitioners and researchers. I would encourage readers to ponder his questions (he provides no answers) and reply with letters to the *Newsletter* Editors, which will be collected and published in a future issue.

Newsletter Associate Editor Jeff Tew also describes in this issue some possibilities for electronic distribution of simulation-related materials, which might become a sort of electronic *Newsletter* as it develops.

Another perhaps less conspicuous leadership role the members of College play involves their broad and deep involvement with the Winter Simulation Conference, in terms of participating in the technical program and exhibits activities, as well as by volunteering their time in the organization and running of the conference. I recently chatted with a colleague from another discipline who lamented the fact that they do not have anything like the WSC to bind them all together regardless of their particular orientation or organization activities. (By the way, don't forget the upcoming WSC — December 8-11 in Phoenix!) Related to this is the College's active role (via the Vice President) in organizing simulation-related sessions at both of the ORSA/TIMS meetings.

But it is perhaps this Newsletter itself that continues to be the single best service that the College provides to its members and to the large simulation community. Since I first became a College member, the *Newsletter* has struck me as the one consistent service that has meant the most in terms of keeping me in touch with what other like-minded individuals are doing. With the expansion of content, the expanded circulation, and other improvements made over the last several years, we can look forward to continued service, and should be grateful to the editors, who have toiled mightily to get the job done.

— David Kelton, President
TIMS College on Simulation

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Advertisements

Editor's Corner

As noted by David Kelton, we are printing two short articles of general interest. This is a practise that we would like to continue. We invite you to send letters or short articles on any topics of general interest concerning simulation. Our aim is to provide a general forum not available in the technical journals or elsewhere. Of course, college business, abstracts, and other regular features will still appear.

Due to space limitations, descriptions of several new simulation texts have been delayed until the Spring issue. These include the second edition of Law and Kelton's *Simulation Modeling and Analysis*, an *Introduction to Simulation using SIMAN* by Pegden, Shannon, and Sadowski, and *Modern Statistical, Systems, and GPSS Simulation: The First Course* by Karian and Dudewicz. Would anyone be interested in providing a short review of any of these books?

Members (and nonmembers!) of the College are reminded that the Business Meeting will be held at ORSA/TIMS in Anaheim: Tuesday (Nov 5) 5:45-6:45 in Balboa C. Refreshments will be served and all are invited.

Please send your abstracts and other materials to either editor — our addresses are on the front cover. Electronic submissions are preferred, but we will accept material in any medium! The editorial deadline for the Spring issue will be 13 March 1992.

—ijs and jdt

College on Simulation

TIMS College on Simulation Newsletter is published twice each year, in the Spring and Fall, by TIMS College on Simulaton. Membership in the College on Simulaton is independent of membership in The Institute of Management Sciences. Annual dues for non-TIMS members is $3; TIMS members may join for $2. Dues for those outside of the U.S./Canada is $3.

To join, send name, address, e-mail address (if applicable), and the appropriate dues to: David Goldsman, School of Industrial and Systems Engineering, Georgia Institute of Technology, Atlanta, GA 30332-0205. Make checks payable to TIMS College on Simulation. Please pass along this announcement to others who might be interested in joining.

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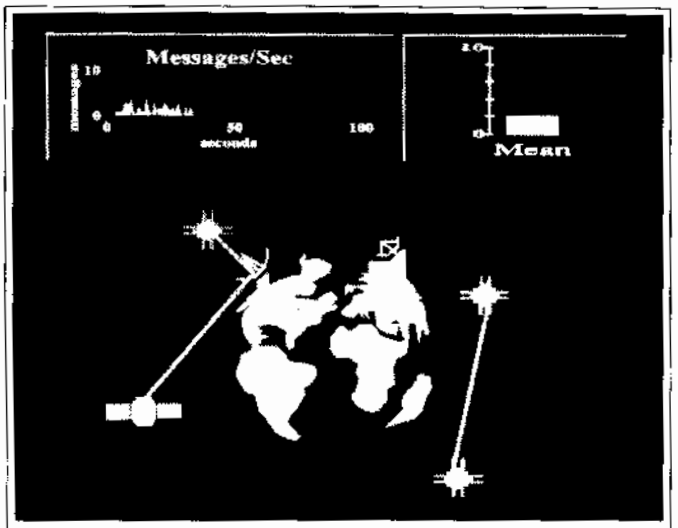

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Some Questions to Start the Discussion

The following list of questions is a three-hour effort in response to the *Newsletter* Editor's request for the first of several short articles that I have promised (or, depending upon your point of view, threatened) to write for the last couple of years. Some of the questions are intentionally loaded, making clear my opinion. Other questions are real; for these questions I have a current opinion that needs to strengthen or wither. The topic definitions are meant to be attacked; I would like better definitions.

Ideally, this list of questions will begin an ongoing discussion in the *Newsletter.* I encourage you to respond, add other questions, and submit short informal articles.

Random-Number Generation
Definition: The choice of mechanism for mimicking a truly random random process having known probability model. (Usually the probability model is that k-tuples are uniformly distributed on the k-dimensional unit cube.)
• What examples do we have of someone trying to create an ad-hoc random-number generator only to have it have a surprisingly short cycle? (Knuth has one. I have one.)
• What examples do we have of a bad random-number generator destroying an experiment? (Other than ad-hoc generators with short cycles.)
• What is the best way to avoid the unpleasantries of a random number rounding to one? (Example unpleasantry: the logarithm of zero when generating an exponential random variate with the inverse transformation x = - log(1-u).) The solution should maintain synchronization, so it will probably be implemented during random-number generation, rather than during random-variate generation.
• What examples do we have of using more than 2^n random numbers in an experiment?
• Why isn't Floyd's algorithm (to ensure that a generator hasn't cycled) mentioned in most textbooks?

Input Modeling
Definition: The choice of a probabilistic model to describe the behavior of stochastic elements of the system.
• What examples do we have of the type of fit materially affecting the fitted distribution? (One example: Maximum likelihood, when the lower and upper bounds of the distribution are parameters.)
• With today's graphics, what arguments exist against using a mouse to fit visually a curve through the empirical distribution function, including extrapolating tails? When is fitting to simple classical models better?
• Same question, but now fitting to expert opinion rather than data.
• How best can we model nonnormal random vectors and time series?

Random-Variate Generation
Definition: Transforming a realization of the random numbers into a realization of the input model.
• Why do some ideas live on? For example,
1) The standard normal approximated by the sum twelve uniforms minus six. Isn't this dominated by the approximation $z = (u^{.135} - (1-u)^{.135}) / .1975$? (And others?)
2) The exponential with mean one as x = -log(u) rather than the inverse transformation x = -log(1-u). The computational savings are trivial, and attempts to induce correlation or to generate order statistics directly are frustrated. (But see the related question under random-number generation.)
3) Other examples?
• State-of-the-art generators are exact and fast; inverse transformation algorithms are sometimes much slower, but are needed for optimal correlation induction. I am interested in exact algorithms that have close to state-of-the-art speed and close to optimal correlation induction. In what contexts would a library of such random-variate generators be useful?
• Does anyone want to argue that the alias method (for generating random variates from a discrete distribution with a finite of mass points) is not dominated by Chen and Asau's indexing method with the number of tabs equal to the number of mass points?

Output Analysis
Definition: Estimating the sampling error of the experiment.
• In what contexts are confidence intervals used that standard errors alone are not sufficient?
• What examples do we have where the method of batching is not close to optimal for estimating standard errors (for whatever purpose)?
• Is any method other than batching applicable, without modification, to point estimators that are not sample means?
• How can we estimate optimal batch size (or equivalently, spectral lag-window width)? Does anyone argue that we should ask the user?
• Often conflict exists between a good design or estimator and a simple output analysis. (For example, using common random numbers to compare systems destroys an independence assumption that simplifies

[continued on p. 6]

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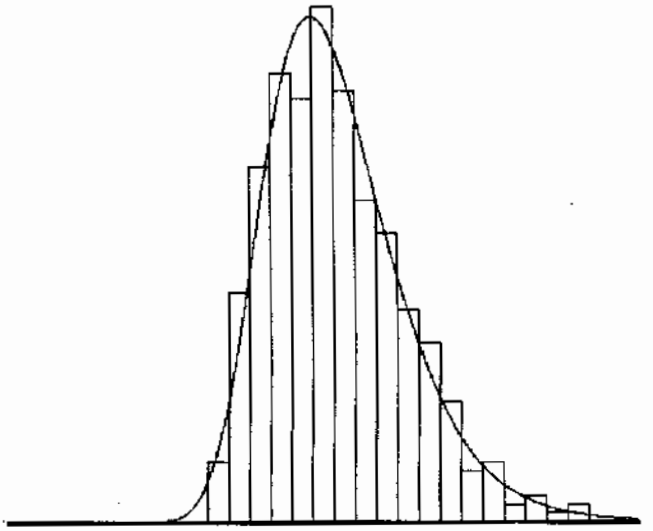

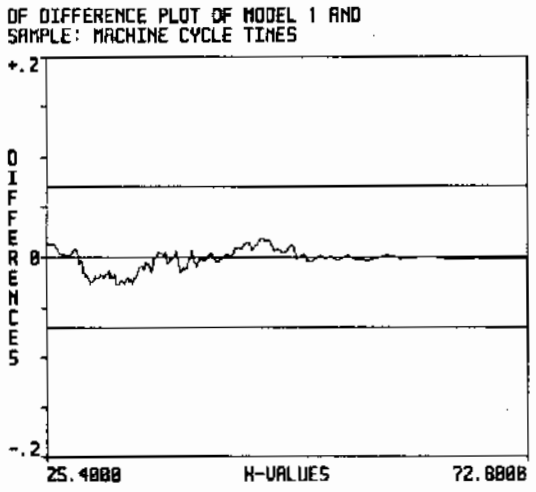

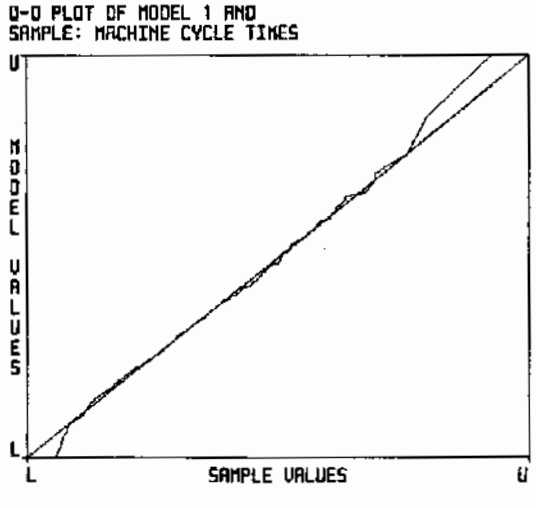

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Some Questions

[continued from p. 4]

some analysis procedures. Or for example, using a point estimator based on all observations is better than the average of estimators from batches.) In every situation that I can imagine, I would use a good design or estimator and do my best with an ad-hoc analysis, maybe by assuming that the better design or estimator makes the simple analysis a conservative bound. Are there situations where I shouldn't?

- Much recent simulation software is designed for use by those that know the real-world system well, but have no (or little) simulation training. Assuming they don't understand confidence intervals or standard errors, how should point estimators be presented in output reports so that the results are properly interpreted?
- Can an argument be made for Bayesian (prior/posterior) analysis of simulation data? In what context?

Testing Hypotheses

- Why does failing to reject a null hypothesis H_0 (e.g., normality, independence) early in an analysis imply that assuming H_0 later is justified?
- Since in simulation we know every detail about the system structure, in what simulation contexts do we not know whether a null hypothesis H_0 is true or false before testing? (One example: I often use Neyman-Pearson hypothesis testing when debugging random-variate generators, although I use only standard errors.)
- Why treat validation as a test of hypothesis? More generally, why ever test a null hypothesis H_0 that is known to be false? In these situations, aren't we really testing whether we obtained enough data (real-world and/or simulated) to have the power to see the difference from H_0 that we know is there?
- Isn't the real problem to estimate the difference from H_0 (e.g., validity) that we know exists and to determine whether that difference has *practical* significance (which depends upon the context) rather than whether the difference has *statistical* significance (which does not depend on the context)?

Meta Modeling

Definition: Approximating expected system response with a simple model whose independent variables are system parameters.

- Why do we (and so much of the rest of the world) often fit linear models using independent and dependent variables in their given form, rather than in forms that provide correct limiting behavior?
- Do neural networks have a role in metamodeling? Anywhere in simulation analysis?

Variance Reduction

Definition: The substitution of one experiment for another for the purpose of reducing the computational effort, or improving the sampling distribution of the point estimator(s), or both.

- Is there any purpose to using more than one random-number stream if not attempting to reduce variance via correlation induction?
- Are there any analytical arguments to support stratifying *within* a random-number stream? For example, stratifying interarrival times? The stratification (often) causes point-estimator bias, but the point estimator's mean squared error is (often) reduced.

Comparing Multiple Systems

Definition: ???

- In ranking and selection, how can we estimate the probability of correct selection rather than simply bound it?
- In what contexts does a simulation analyst use formal methods (e.g., ranking and selection, multiple comparison procedures) for comparing a set of given systems?

Many people will find some of the questions familiar. Although I haven't discussed this specific list with anyone else, much of it is the result of many interesting discussions with former students, current students, Purdue colleagues, and others, so many of whom have been active in the TIMS College on Simulation.

Bruce Schmeiser
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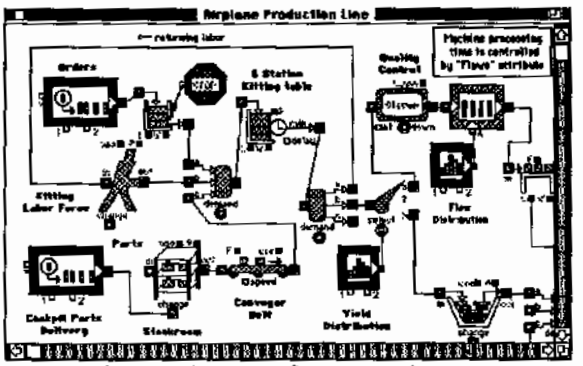

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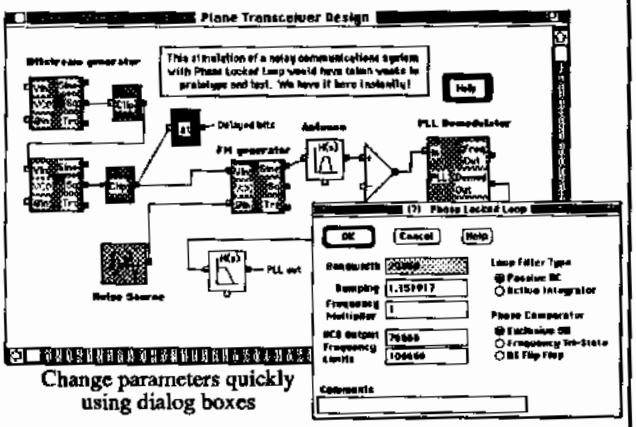

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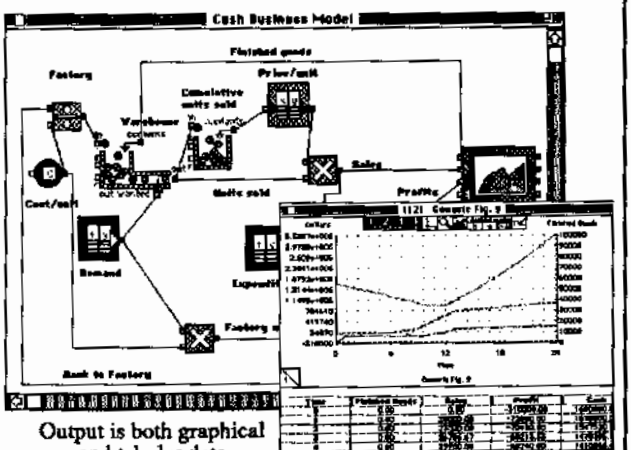

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Change of Vantage Point

By Jim Swain

I recently joined Lionheart Publishing to edit *ISR: Intelligent Systems Report*, with an opportunity to contribute to *OR/MS Today*. I am learning about the application of intelligent computing — expert systems, neural networks, and the like. Besides the topical shift, there is the shift from primarily writing to other researchers to the more general audiences of these publications. Though new to it all, here are some observations on our field from my new vantage point.

I. Products for work ...

The October issue of *OR/MS Today* features a survey of software for discrete event simulation on microcomputers and workstations. While not as comprehensive as the SCS *Directory of Simulation Software* (1990), it is noteworthy how many products there are and the range of capabilities (and prices). About four dozen companies are represented, from around the world.

Simulation products clearly mirror developments in software generally, with improvements in input and output, specialization among products, and integration with other products. Model building is increasingly mediated by graphical or menuing systems, and outputs come in a variety of formats. Animation is clearly here to stay; many products can produce animation, either directly or through another product.

A number of specialized simulation products were noted. There are programs to assist in building factory simulations, simulations of communications networks, among other things. CACI, for instance, has COMNET II.5, LANNET II.5 , and SIMFACTORY II.5. There are also programming development tools, such as MOGUL for GPSS/H and ISI-PC for SIMAN. In the other direction, simulation products are increasingly integrated with other products for data analysis and report writing, and with design tools. So we see simulations that can read CAD data formats (e.g., CADmotion and Proof), or build and maintain databases of run results (e.g. SLAM/TESS and the MAST Simulation Environment). In a similar way, data generated by Manuplan, a roughcut modelling program, can be the basis of a more detailed simulation later on using the SIMSTARTER program (or SIMAN or SLAM). Objects have been with simulation for a long time and have now become increasingly popular: DISC++, FMS++, MODSIM II, PASION, and PC Simula are examples noted in the survey.

II. ... and for Play!

Most games are animated simulations, ranging from the crude to the realistic. One can now simulate the piloting of aircraft, navigate singles' bars, or drive tanks or submarines in varying levels of detail. Several more recent games seem closer to simulation as most of us think of it: depictions of systems where the object is to run an operation or perhaps to learn something new. Railroad Tycoon (Microprose Software), which Pournelle has twice featured in his column in *Byte*, requires you to run an entire railroad. And Maxis Software has SimCity (run a city government) and SimEarth (control the evolution and development of the earth). In the future we may see games like "TroubleShoot", where the company is saved using improved quality control or "JustInTime", where a simulated production facility requires better scheduling to turn a profit.

III. Advice to the User

Is the widespread availability of easy to use simulation software an unmixed blessing? Ease of use means that there will be more use made of the technology, but will the users always employ the tools "properly"? The ASA has had panels at their national meetings on the "misuse" statistical packages. In our case, vendors tell me that there are still too many examples of users running their laboriously developed simulation models once for each case and ignoring the variability of the output altogether.

Most users are close to the process that they want to study and know what the model must do. For many, all their energies have been devoted to getting the model up and validated — analysis becomes an afterthought. Of course, some users simply don't appreciate that a mistake is being made, while others find statistics either confusing or intimidating, and therefore best avoided. And finally, there are those who end up doing something more sophisticated than they really need or are in a position to use properly. In all of these cases some clear, fairly uniform principles of practice might help.

Any list of principles should be a rather compact, stated emphatically, and should not aim for comprehensiveness or optimality. My own impression is that users wouldn't mind a few extra runs using a simple strategy in favor of an optimal one that they aren't comfortable with. A sort of minimax approach seems right: we want to minimize the maximum errors that a naive user could make.

One such list is proposed by Barry Nelson and

[continued on p. 10]

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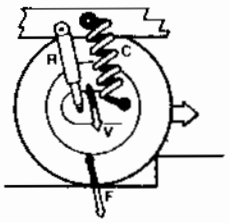

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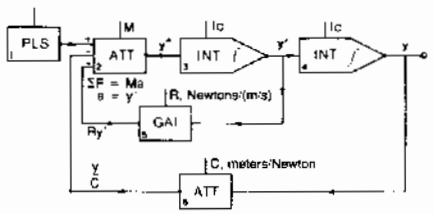
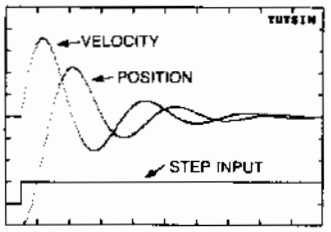
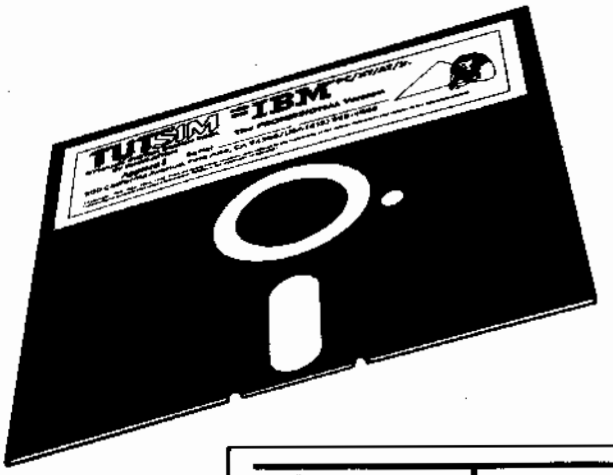
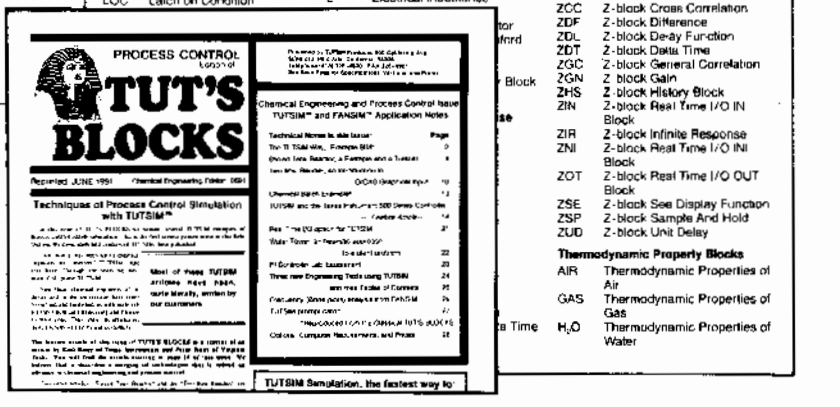
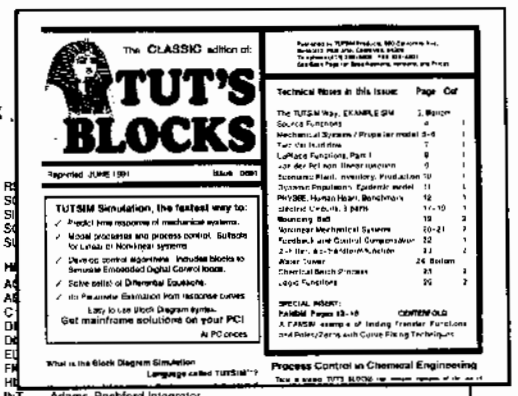


Results:









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Vantage Point
[continued from p. 8]

appears in his Chapter, "Statistical Analysis of Simulation Results," in the *Handbook of Industrial Engineering* (2nd edition), G. Salvendy, ed. (1991), Wiley, NY. Paraphrasing his first eight principles we have:

1) Random number seeds should be considered part of the overall experimental design.

2) Outputs within a run are typically (statistically) dependent and for a fixed run length, the number of observations may be random.

3) For i.i.d. observations, the sample average is unbiased and standard errors decrease as k^{-1}, where k is the number of independent replicates.

4) Probabilities can be computed using averages of indicator random variables, where the indicator random variable has value 1 for an event of interest, and otherwise 0.

6) Every point estimate should have some sort of an error estimate.

7) The number of digits in a solution should be limited by the error achieved, the larger the error, the fewer digits. The last digit used may be uncertain.

8) There is a possibility of bias in steady state simulations, depending upon the starting conditions and the time it takes to "warm up" the system. In this case, increasing the number of replications while shortening the run length may increase the bias.

Most of us are already aware of these principles and understand their implications. The question is whether the typical user understands these points (or any other set of fundamental ones). On the whole we would probably do a bigger service to our community to improve the basic analysis of simulations used in practice than to insure that variance reduction methods are employed. One veteran simulation manager directed a colleague recently to focus on design and not to worry about variance reduction. From the cost perspective, he argues, it is cheaper to make a few extra runs than it is to get a variance reduction scheme to work. This is not an attack on variance reduction. In any case, variance reduction methods are not likely to be used by novice users.

V. AI and all that

I am a newcomer to the AI scene, but I already impressed with the possibilities that this technology already provides. One product particularly caught my attention, Gensym's G2, a real-time expert system (ES) with a considerable simulation capability. G2 has a simulator built into it and also includes the ability to interface with other simulators. According to Andreas Hofmann, manager of simulation products, G2 can use simulation in several ways. For instance, while building an expert system to control some real process, a simulation can be used in place of the real system. Or, while the expert system is running a process, a simulation can be used to predict what the system is likely to be doing in the future. Finally, when operators are being trained, the expert system and its object (a simulation) can be run as a simulation, as pilots are trained in a flight simulator.

In the process control arena, simulation can be used to help infer what is going on when there is an incompletely instrumented process or there is a possibility that some sensors may be in error. For instance, everything reads "ok", but the behavior of the real system diverges from that of a simulation: has a sensor gone bad, and if so, which one? Or, what part of the process, not directly observed, is causing the problem? One could say that the simulation mechanism would be an integral part of the expert system in such a case.

The interaction between AI and simulation need not be limited to the cases in which the simulation assists the ES. Consider the principles of output analysis advanced earlier. Suitably enlarged, could an output analysis ES be constructed that could be used to assist in the planning of simulation runs, or perhaps even to execute the design and perform the analysis?

Finally, an ES might be part of the simulation. The ES might "simulate" the behavior of a decision maker. Simulation might be used to test how a prototype ES would perform in practice, if left to run on its own; in fact, an output analysis ES would likely be tested in just this way — simulating how it would run simulations, and how good the results were.

This last July I attended The Innovative Applications of AI show, a showcase of what were considered among the most innovative of AI applications. Northwest Airlines fielded a system which permitted them to audit 100% of their tickets, both the fares and the commissions paid to travel agents. Conceptually the system was not extremely complex; much of the challenge was in combining the scanned ticket images, the fare information, and the commission agreements in a manner which could be used by the system. And this suggests that if simulation becomes more pervasive — in effect, mirroring actual operations as they run, or checking every design as it is made, ES can also play a role in collecting the data and making it available for the simulation, and, in turn, "monitoring" the results and preparing the results for analysis.

Much of this is speculative, but I suspect that there are many possibilities for interaction between these two technologies.

International Journal of Computer Simulation

The International Journal of Computer Simulation will present state of the art research and development in the area of modeling methodologies; discrete-event, parallel discrete-event, distributed, file and data base, continuous, dynamic, military, agricultural, and economic simulations; simulation of manufacturing and production environments; simulation as a design tool; and related simulation topics.

The journal will be of interest to all those concerned with research, development, and modeling in this technology especially, engineers, computer scientists, and allied disciplines. The journal will publish original state of the art research, development, product development, and state of the art tutorials.

All papers submitted to the International Journal of Computer Simulation will be refereed by an international review board

Send manuscripts and outlines for special issues (see below) to:

Dr. George W. Zobrist, Editor
Department of Computer Science
University of Missouri-Rolla
Rolla, MO 65401
(314) 341-4836 or -4492
c2816@umrvmb.umr.EDU

Some recent special issues of the Journal have included "Multiple Processor System Simulation", "Digital Logic Simulation" and "Distributed File/Data Base System Simulation."

Treasurer's Report

For the period 3/15/91 - 8/31/91, the College had the following transactions at the Wachovia Bank of Georgia, Atlanta, GA. (formerly First National Bank of Atlanta).

Balance Forward (Checking account + CD which matured 7/19/91) $26642.08

Revenues		
Interest from checking account and CD	1046.90	
Reimbursement from 1990 WSC	4000.00	
Dues	14.00	
Refund of bank service charges	15.00	
Total Revenues		5075.90
Disbursements		
Bank service charge	3.00	
Seed money for 1991 WSC	2000.00	
Reimburse Steve Roberts for travel to Board mtg	566.50	
Total Disbursements		2569.50
Net (revenues - disbursements)		2506.40
Balance Forward		29148.48

In addition to the above funds, the College has on account at TIMS Headquarters approximately $1000.00 (as of 8/31/91), bringing the College's net worth to $30148.48.

Respectfully submitted,
David Goldsman, Secretary-Treasurer
September 25, 1991

••••••••• How to join TIMS College on Simulation •••••••••

You can join the College on Simulation even if you aren't a member of The Institute of Management Sciences. The cost of annual dues for non-TIMS members of the College is only $3; TIMS members pay only $2. To join, please fill out this form and send it, along with a check for the appropriate amount, to: **David Goldsman, School of Industrial and Systems Engineering, Georgia Institute of Technology, Atlanta, GA 30332-0205.** Make your check payable to "TIMS College on Simulation."

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Address _____

City _____ State _____ Zip _____

E-mail address (if applicable) _____

NOTE: If you know people who might be interested in joining, please pass along this announcement.

Minutes of College Meeting at TIMS/ORSA Nashville

Members attending: Jon Hill, Dean Hartley, Chuck Reilly, Barry Nelson, Sigrun Andradottir, John Charnes, Dave Kelton, Bob Sargent, Sheldon Jacobson, Wheyming Song, Michael Ketcham, Osman Balci, Dave Goldsman, Gordon Clark, Paul Glasserman, Russell Barton, Doug Morrice, Christos Alexopoulos, Jeff Tew, Neal Bengston, Jim Wilson, Thanos Avramidis, Lynne Goldsman, Marc Meketon
Nonmembers attending: Dan Brunner, Raj Veeramani, Huifen Chen, Jim Calvin, Laurel Travis, Mary Ann Flanigan, Aarti Shanker, Murali Shanker

1. Dave Kelton called the meeting to order at 6:20 p.m. on May 14, 1991.
2. The attendees introduced themselves.
3. Dave Goldsman read the Treasurer's report and Minutes of the 1990 WSC business meeting; they were approved.
4. Barry Nelson gave the Vice President's report. He discussed the poor session scheduling at Nashville; in response to the poor scheduling, Barry wrote a letter of complaint to Don Morrison. Bob Sargent moved that the Secretary send letters to the ORSA/TIMS Council, and to the General Chairpersons of the Nashville and Anaheim meetings. Barry made a friendly amendment that he (Barry) write these letters. Barry also noted that he will assemble four Anaheim sessions sponsored by the College.
5. Jeff Tew gave the *Newsletter* Editor's report. Jeff will look into the implementation of an electronic bulletin board. (Paul Fishwick already runs a related board.)
6. Dave Kelton reported that our 1990 WSC reimbursement will be $4000.
7. Dave Kelton reported that nominations for the Publication Award will be accepted through May 31. The Award will cover qualifying publications from1986 to 1989.
8. Dave Kelton reported that nominations for the Distinguished Service Award will be accepted through September 1.
9. Jim Wilson discussed the Simulation Department at Management Science as well as the Departmental and Associate Editors meeting with Editor in-Chief Gabriel Bitran. Jim proposed to make a mass mailing to inform people of the Department's updated editorial policy. Gordon Clark moved that we underwrite the mailing. The motion passed.
10. Dave Kelton passed around a report from Lionheart Publishing Co. concerning a monograph series. John Llewellyn (of Lionheart) discussed the report with us. Dave Kelton motioned that we continue study. The motion passed.
11. Bob Sargent motioned that students participating in the Ph.D. Colloquium receive a $100 expense reimbursement; the conditions of the reimbursements would remain the same as those already in effect. The motion passed.
12. The meeting was adjourned at 7:40 p.m.

Respectfully submitted,
David Goldsman, Secretary-Treasurer, September 30, 1991

Status Report on the Simulation Department of *Management Science*

Since the first of this year, 15 new papers have been submitted to the Simulation Department of *Management Science*; and editorial work has been completed on 14 papers, with 8 papers accepted, 4 papers rejected, and 2 papers withdrawn. To put these figures in perspective, we note that since January 1, 1988, editorial work has been completed on 54 papers, with 14 papers accepted, 36 papers rejected, and 4 papers withdrawn. Thus the overall acceptance rate for the Department during the past 3 years and 9 months is about 26%, which is consistent with the acceptance rate of 20% for the entire journal during the same period.

Currently the Simulation Department has 23 papers in process, including 1 late paper. A paper is considered late when 6 months have elapsed without editorial feedback being provided to the author(s). We are making a concerted effort to eliminate late papers entirely, and we would greatly appreciate the cooperation of all Referees in achieving this goal. Individuals who are asked to referee a paper should adhere strictly to Littlewood's "zero infinity" law—when a paper is received, a decision on whether or not to referee the paper should be made, carried out, and communicated to the appropriate Associate Editor *immediately*.

At the request of Professor Gabriel Bitran, the new Editor-in-Chief of *Management Science*, a mass mailing was sent in early September to the current members of the College on Simulation and to the registrants of the 1990 Winter Simulation Conference. The objective of this mailing was to attract a larger number of high-quality submissions by highlighting the activities of the Department in publishing archival papers on a wide range of topics in the field of simulation. In conjunction with this mailing, we prepared a revised Editorial Policy Statement for the Department. The new Editorial Policy Statement appears in this issue of the *Newsletter* and will also appear in the September issue of *Management Science*.

Editorial Policy Statement for the Simulation Department of *Management Science*

The Simulation Department seeks to publish high-quality papers dealing with any aspect of system simulation that is relevant to the practice or theory of management science. Thus the scope of the Department encompasses discrete and continuous simulation on the one hand as well as deterministic and stochastic simulation on the other. In all cases, however, a proposed technique should have a clearly identified potential use as an aid in decision making. Papers that are suitable for consideration under these broad guidelines will be reviewed fairly, thoroughly, and expeditiously. The decision to publish a paper will be based on three criteria: (a) importance of the problem to be solved, (b) originality and effectiveness of the proposed solution, and (c) accuracy and clarity of the exposition. For papers belonging to one of the general categories of *theory*, *methodology*, and *applications*, the following considerations apply.

Theory. The Department seeks fundamental contributions to simulation modeling and analysis. The theory of simulation modeling includes the principles of computer science and general systems theory that underlie the techniques for building simulation models, and the theory of simulation analysis includes the principles of probability and statistics that underlie the techniques for designing and analyzing simulation experiments. The level of mathematics in theory papers should be appropriate to the topic but is otherwise unrestricted. In every case, however, the abstract and introduction should be accessible to the general readership of *Management Science*. The Department also encourages survey papers that synthesize state of-the-art research results in a unified treatment of a given topic, thereby providing researchers and advanced practitioners with an introduction to recent developments in that area.

Methodology. Within this category, some of the major topics of interest are: methods for modeling, fitting, and generating stochastic input processes; concepts and techniques for general systems modeling; simulation languages; simulation support environments (including concepts, procedures, and software systems for development, management, and execution of simulation models); verification and validation techniques; experimental designs for simulation; output analysis methods; variance reduction techniques; methods for optimization and sensitivity analysis; parallel and distributed simulation; systems dynamics; and simulation-based techniques for policy modeling and analysis. The presentation of a new methodology should include an analytical or experimental comparison of the proposed method with existing methods. For example, the experimental evaluation of a new output analysis procedure should be based on simulation of meaningful target systems for which theoretical performance characteristics are known so that proposed and existing estimation procedures can be compared with respect to accuracy, reliability, and efficiency. Moreover, such an experimental evaluation should be described in sufficient detail so that the results can be replicated.

Applications. The Department is interested in publishing case studies that provide lessons of transferable value about the use of simulation to support decision making. Such studies should be distinguished by innovative approaches to the use of modeling and analysis techniques. Moreover, papers in this area should emphasize the way in which knowledge gained from simulation experiments was used to shape general policies or to make specific decisions about the problem at hand.

Authors should submit their papers to the Department Editor:

James R. Wilson
Department of Industrial Engineering
North Carolina State University
Box 7906
Raleigh, NC 27695-7906
(919) 515-2363, FAX: (919) 515-5281
INTERNET: jwilson@eos.ncsu.edu

The Associate Editors for the Simulation Department are: Russell C. H. Cheng of the University of Wales, Pierre L'Ecuyer of the University of Montreal, Peter W. Glynn of Stanford University, David Goldsman of the Georgia Institute of Technology, and Stephen D. Roberts of North Carolina State University.

E-Mail Directory Update

Below is the latest update of the e-mail directory. If you would like to have your address included, please send it the the Newsletter editors at iefacdg@gitvm1.bitnet or iele95@vtvm2.bitnet.

NAME	AFFILIATION	E-MAIL ADDRESS
Christos Alexopoulos	Georgia Tech	calexopo@gtri01.bitnet
Mike Bailey	NPS	5028p@navpgs.bitnet
Osman Balci	Virginia Tech	balci@vtopus.cs.vt.edu
Russell Barton	Penn State U.	barton@simplex.psu.edu
Ken Bauer	AF Inst. Tech.	kbauer@galaxy.afit.af.mil
Diane Bischak	NC State	bischak@ncsuie.bitnet
Ted Brown	Queens College	brownt@qcvax.bitnet
Frank Chance	Cornell	chance@orie.cornell.edu
John Charnes	U. Miami	jcharnes@umiami.miami.edu
Russell Cheng	U. Wales	cheng@cardiff.ac.uk
Gordon Clark	Ohio State	clark-g@eng.ohio-state.edu
Tom Clark	Florida State	tclark@fsuavm.bitnet
John Comfort	Florida International	comfort@servax.bitnet
Ron Dattero	Florida Atlantic U.	dattero@fauvax.bitnet
Luc Devroye	McGill U.	luc@mujunior.cs.mcgill.ca
Remko Dur	Delft Tech	winfdur@hdetud1.tudelft.nl
George Fishman	U North Carolina	uncgsf@unc.bitnet
Paul Fishwick	U. Florida	fishwick@fish.cis.ufl.edu
Bob Foley	Georgia Tech	rfoley@gtri01.bitnet
Ben Fox	U. Colorado	bfox@cudenver.bitnet
Michael C Fu	U of Maryland	mfu@umd5.umd.edu
Masanori Fushimi	U. Tokyo	fushimi@misojiro.t.u-tokyo.ac.jp
James Gentle	IMSL	uunet!imsl!gentle
Paul Glasserman	Columbia U.	fapglass@cugsbvm.columbia.edu
Peter Glynn	Stanford	glynn@leland.stanford.edu
Dave Goldsman	Georgia Tech	dgoldsma@gtri01.bitnet
David Grier	George Washington U.	dagrier@gwuvm.bitnet
Jorge Haddock	RPI	ffye@rpitsmts.bitnet
Phil Heidelberger	IBM	berger@ibm.com
Sheldon Jacobson	Case Western	jacobson@pyrite.som.cwru.edu
Mary Johnson	U. Illinois	maryjohn@ux1.uiuc.edu
Keebom Kang	NPS	5030p@navpgs.bitnet
Dave Kelton	U. Minnesota	dkelton@vx.acs.umn.edu
Jack Kleijnen	Tilburg , Netherlands	kleijnen@kub.nl.bitnet
Robert Klein	Regenstrief Inst.	icjd100@indyvax.edu
Pierre Lecuyer	U. Montreal	lecuyer@iro.umontreal.edu
Peter Lewis	NPS	1526p@navpgs.bitnet
J Jung Lyu	Iowa	aeglynpa@uiamvs.bitnet
D.C. McNickle	U. Canterbury, NZ	opre001%canterbury.ac.nz@relay.cs.net
Susumu Morito	Waseda, Japan	opremori@jpnwas00
Edward Mykytka	AF Inst. Tech	emykytka@galaxy.afit.af.mil
Richard Nance	Virginia Tech	nance@vtopus.cs.vt.edu
Barry Nelson	Ohio State	nelsonb@random.eng.ohio-state.edu
Harald Niederreiter	U. Vienna	nied@qiinfo.oeaw.ac.at
Norman Nielsen	SRI International	nielsen@sri.com

Ashvin Radiya	Wichita State U.	radiya@sulu.wsu.ukans.edu
R. Joel Rahn	Laval University	rahnj@vm1.ulaval.ca
Charles Reilly	Ohio State	reilly-c@eng.ohio-state.edu
Steve Roberts	NC State	sroberts@ncsuie.bitnet
Paul Sanchez	Arizona	paul@tucson.sie.arizona.edu
Bob Sargent	Syracuse University	rsargent@top.cis.syr.edu
Bruce Schmeiser	Purdue	schmeise@ecn.purdue.edu
Tom Schriber	Michigan	userk2bu@umichub.bitnet
Lee Schruben	Cornell	lee@orie.cornell.edu
Andy Seila	U. Georgia	aseila@uscn.bitnet
Robert Shannon	Texas A&M	res2568@tamsigma.bitnet
Henk G. Sol	Delft Tech	winfsol@hdetud1.tudelft.nl
Wheyming Tina Song	Natl. Tsing Hua U.	wsong@twnctu01.bitnet
Ernst Stadlober	TU-Graz, Austria	statistik@rech.tu-graz.ada.at
Bob Storer	Lehigh	rhs2@lehigh.bitnet
Steve Strickland	U. of Virginia	sgs8r@kelvin.edu
Jim Swain	Lionheart Pub.	iefacdg@gitvm1.bitnet
Mike Taaffe	U. of Minnesota	taaffe@ux.acs.umn.edu
Pandu R. Tadikamalla	U. of Pittsburgh	pandu@pittvms.bitnet
Jeff Tew	Virginia Tech	ieie95@vtvm2.bitnet
Enio Velazco	Worcester Poly	evelazco@wpi.wpi.edu
Alexaner Verbraeck	Delft Tech	winfave@hdetud1.tudelft.nl
Peter Welch	IBM	welch@ibm.com
Folkert W. Wierda	Delft Tech	winffww@hdetud1.tudelft.nl
Ward Whitt	AT&T Bell Labs	wow@research.att.com
Rosemary Wild	U. Hawaii	wild@uhccvx.uhcc.hawaii.edu
Jim Wilson	NC State	jwilson@eos.ncsu.edu
Dave Withers	Mead Data Central	davew@meaddata.com
Jeff Wright	Purdue	wrightje@simplex.ecn.purdue.edu
Helio Yang	San Diego State	hyang@sciences.sdsu.edu
Enver Yucesan	INSEAD	yucesan@freiba51.bitnet

Simulation Electronic Bulletin Board

Work has begun on establishing an electronic bulletin board for the TIMS College of Simulation. The bulletin board will be resident on vtvm2 at Virginia Tech and administered by Jeff Tew. Its configuration will allow for the automatic retrieval of any information maintained on the bulletin board through standard email channels. Direct placement of information on the bulletin board will be restricted to the bulletin board manager (Jeff Tew). However, we encourage you to send information you wish to have placed on the bulletin board to:

Prof. Jeffrey D. Tew
ISE Department
302 Whittemore Hall
Virginia Tech
Blacksburg, VA 24061
Phone: (703) 231-7099
FAX: (703) 231-3322
e-mail address: ieie95@vtvm2.bitnet

Requests for placement of information onto the bulletin board will be promptly processed. Currently, we plan on maintaining an e-mail address list of TIMS College of Simulation members as well as a list of recent article abstracts of relevant papers in the leading journals (e.g., IIE Transactions, JSCS, Management Science, Operations Research, etc.). Please send any ideas for other items that should be placed on the bulletin board to Jeff Tew at the above address. We anticipate that the bulletin board will be functional by early November of this year.

Abstracts

"Integrating and Accelerating Tabu Search, Simulated Annealing, and Genetic Algorithms," Ben Fox, Department of Mathematics, University of Colorado at Denver, Denver, CO

We integrate tabu search, simulated annealing, and genetic algorithms. In addition, we speed up the combination by a factor going to infinity as the number of transitions generated goes to infinity. Beyond this, nearly linear speed-up often can be expected in the number of independent parallel processors.

"Control-Variate Models of Common Random Numbers for Multiple Comparisons with the Best," Barry L. Nelson and Jason C. Hsu, Department of Industrial and Systems Engineering, The Ohio State University, Columbus, OH

Using common random numbers (CRN) in simulation experiment design is known to reduce the variance of estimates of differences in system performance. However, when more than two systems are compared, exact simultaneous statistical inference in conjunction with CRN is typically impossible. We introduce control-variate models of CRN that permit exact statistical inference, specifically multiple comparisons with the best.

"The Fourier-series Method for Inverting Transforms of Probability Distributions," Joseph Abate and Ward Whitt, Ridgewood, NJ

This paper reviews the Fourier-series method for calculating cumulative distribution functions (cdf's) and probability mass functions (pmf's) by numerically inverting characteristic functions, Laplace transforms and generating functions. Some variants of the Fourier-series method are remarkably easy to use, requiring programs of less than 50 lines. The Fourier-series method can be interpreted as numerically integrating a standard inversion integral by means of the trapezoidal rule. The same formula is obtained by using the Fourier series of an associated periodic function constructed by aliasing; this explains the name of the method. This Fourier analysis applies to the inversion problem because the Fourier coefficients are just values of the transform. The mathematical centerpiece of the Fourier-series method is the Poisson summation formula, which identifies the discretization error associated with the trapezoidal rule and thus helps bound it. The greatest difficulty is approximately calculating the infinite series obtained from the inversion integral. Within this framework, lattice cdf's can be calculated from generating functions by finite sums without truncation. For other cdf's, an appropriate truncation of the infinite series can be determined from the transform based on estimates or bounds. For Laplace transforms, the numerical integration can be made to produce a nearly alternating series, so that the convergence can be accelerated by techniques such as Euler summation. Alternatively, the cdf can be perturbed slightly by convolution smoothing or windowing to produce a truncation error bound independent of the original cdf. Although error bounds can be determined, an effective approach is to use two different methods without elaborate error analysis. For this purpose, we also describe two methods for inverting Laplace transforms based on the Post-Widder inversion formula. The overall procedure is illustrated by several queueing examples.

"Integrated Modeling System for Patrol Boats Acquisition in the U.S. Coast Guard," Hemant K. Bhargava and Keebom Kang, NPS Technical Report, Naval Postgraduate School, Monterey, CA

We discuss the development and application of an integrated modeling system for fleet mix planning in the U.S. Coast Guard, in the context of acquisition of a mix of patrol boats. Alternative fleet mixes are compared by evaluating cost, activity, and mission performance measures. We develop a model that evaluates the responses of a given fleet mix to events occurring during simulation of the Coast Guard's operating environment. It is hoped that analysis of alternative fleet mixes using a large number of data sets, and post-evaluation analysis and explanations, will help provide the decision-makers insight into the problem, and will facilitate a judicious decision.

"Smoothed Perturbation Analysis for General Discrete-Event Systems," Michael C. Fu, College of Business and Management University of Maryland, and Jian-Qiang Hu, Dept. of Manufacturing Engineering, Boston University

Smoothed perturbation analysis is a technique for estimating derivatives of performance measures of a stochastic discrete-event system. The key idea is the use of conditional expectation to "smooth" certain discontinuities which prevent the use of infinitesimal perturbation analysis. The source of these discontinuities may be the performance measure or the underlying stochastic processes. Previous work

has considered special classes of performance measures under a structural condition on the system called the commuting condition. The resulting estimators are very attractive, in that they can be easily estimated from a single sample path (or simulation) of the system. However, most multi-class queueing networks, as well as systems as simple as the GI/G/1/K queue, cannot be handled. Under a framework allowing quite general performance measures for systems that do not necessarily satisfy the commuting condition, we derive two derivative estimators (a left-hand derivative estimator and a right-hand derivative estimator, equal in expectation) and prove their unbiasedness. Our estimators are applicable in quite general settings, and in particular can handle multi-class queueing networks and the GI/G/1/K queue. However, the gain in generality comes at a cost, in that the derivative estimator contains terms which may not be easily estimated from a single sample path, and thus may require additional simulation. The framework is such that upon application of the commuting condition and restriction to certain classes of performance measures, we readily recover as special cases of our estimators the estimators of previous researchers.

"TES: A Class of Methods for Generating Autocorrelated Uniform Variates," Benjamin Melamed, NEC Research Institute, Princeton, NJ

The paper introduces a class of methods called TES (Transform-Expand-Sample) for generating autocorrelated variates with uniform marginals and Markovian structure. TES methods are readily implemented on a computer and have generation complexity comparable to that of the i.i.d. uniform sequence which they transform to an autocorrelated uniform sequence. For any prescribed correlation coefficient ρ, there is a TES method generating a uniform sequence with the 1-lag autocorrelation ρ, and the resultant autocorrelation is monotonic quadratic in two structural TES parameters. A simulation study reveals that TES methods give rise to autocorrelation functions with monotone decreasing as well as oscillating magnitude, bounded by monotone envelopes. The structural parameters were found to control the "amplitude" and "frequency" of the resultant autocorrelation function. A third parameter can be used to transform a TES sequence into more continuous-looking versions and to control the skewness of sample path cycles.

"Sensitivity Analysis of Queueing Networks using Heuristic Score Function Methods," Yuval Lirov, AT&T Bell Laboratories, Holmdel, NJ, and Benjamin Melamed, NEC Research Institute, Princeton, NJ

We propose a heuristic Score Function methodology for estimating gradients of mean sojourn times in queueing networks. The heuristic idea is to treat each queue separately and "asynchronously," pretending that individual queue cycles constitute local regenerative cycles. The efficacy of our approach is demonstrated through an example from the domain of Jackson queueing networks.

"Spectral Analysis of Some Transformed Modular Autoregressive Processes," David L. Jagerman and Benjamin Melamed, NEC Research Institute, Princeton, NJ

This paper studies the spectral properties of a class of modular stochastic sequences generated by TES (Transform-Expand-Sample) methods, as well as transformations of TES sequences. A TES sequence is obtained from an autoregressive modulo-1 scheme. We derive formulae for the spectral density and the integrated spectrum which are suitable for efficient numerical computation. A set of examples are calculated and exhibited for a variety of transformations. The results contribute to the understanding of TES sequences as models of correlated sequences, particularly in a Monte Carlo simulation context.

Event Calendar

Simulation Technology Conference International, October 21-23, Orlando Twin Towers, Orlando, FL. Contact Mary Lou Padgett, 1165 Owens Road, Auburn, AL 36830, (205) 821-2472.

TIMS/ORSA Joint National Meeting, November 3-6, Hilton Hotel, Anaheim, CA. Contact Carlton Scott, Graduate School of Management, University of California, Irvine, CA 92717, (714) 856-5336.

1991 Winter Simulation Conference, December 8-11, Phoenix, AZ.Contact Gordon Clark, Department of Industrial and Systems Engineering, The Ohio State University, 1971 Neil Avenue, Columbus, OH 43210, (614) 292-7863.

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ORSA Computer Science Technical Section Conference, January 8-10, Fort Magruder Inn & Conference Center, Williamsburg, VA. Contact Osman Balci, Department of Computer Science, McBride Hall, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061, (703) 231-4841.

ORSA Conference on Telecommunications, March 9-11, Boca Raton, FL. Contact David Yao, IEOR Department and Center for Telecommunications Research, 312 Mudd, Columbia University, New York, NY 10027-6699, (212) 854-2934.

TIMS/ORSA Joint National Meeting, April 26-29, Marriott World Center, Orlando, FL. Contact Bill Swart, Industrial Engineering Department, University of Central Florida, Orlando, FL 32816.

IIE Industrial Engineering Research Conference, May 20-21, Hyatt Regency O'Hare, Chicago, Illinois. Contact Ed Unger, 207 Dunstan Hall, Auburn University, AL 36849-5346, (205) 844-1400.

TIMS/ORSA Joint National Meeting, November 1-4, Hilton Hotel, San Francisco, CA. Contact Chaiho Kim, The Leavey School of Business, University of Santa Clara, CA 95053.

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