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A RETROSPECTIVE ORAL HISTORY OF COMPUTER SIMULATION: PROGRESS REPORT

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ABSTRACT

The primary objective of the project titled "A Retrospective Oral History of Computer Simulation" is to document the emergence of computer simulation since World War II. We seek to capture the early history of the field through digital videos of interviews with the pioneers whose seminal contributions have had long-lasting impacts on simulation practice and theory. This project involves the following activities: (a) identifying those pioneers who are to participate in the project; (b) making the logistical arrangements necessary to produce high-quality digital-video recordings of structured interviews with those pioneers; and (c) carrying out the interviews, editing the recordings, and posting those recordings in a universally accessible permanent digital repository. The digital videos produced by this project will be made freely available on the Web site of the Simulation Archive hosted by the North Carolina State University Libraries. We discuss progress to date and future plans for the project.

1 INTRODUCTION AND BACKGROUND

1.1 The Historical Roots of Computer Simulation

The history of simulation precedes that of the digital computer by over 200 years, but the advent of the general-purpose electronic computer transformed Monte Carlo simulation from a brute-force, human-intensive, overly demanding problem-solving technique to one that was effective, efficient, broadly applicable, and extremely popular; see Burks and Burks (1981), Cooper (1989), Hammersley and Handscomb (1964), Pearson (1990), Todhunter (1965), and Goldstine (1972). The *application* of Monte Carlo in the repetition of statistically independent trials required the discovery of a method for producing *uncertainty* in computational machines that were inherently deterministic because of a finite word-length and a finite population of numerical representations. The work of Ulam, Metropolis, and von Neumann at Los Alamos using the middle-of-the-square (MOS) technique for producing pseudorandom numbers seemed a sufficient answer to this question (Cooper 1989, Metropolis 1987). However, the lack of a theoretical basis for MOS and the failings frequently encountered in experimental use led to recognition of the need for a better method of random number generation (RNG). In 1948 Derrick Lehmer addressed this need by formulating two methods for producing linear congruential RNGs (Lehmer 1951). Expansion in the size

of internal memory in the early- to mid-1950s extended the period of linear congruential RNGs, making their applicability more apparent in their use in Monte Carlo experiments (Knuth 1998).

A different group of engineers and scientists envisioned applications of the experimental technique in areas where time-sequenced events governed the representation of state transitioning in manufacturing systems, typically described as job shop scheduling. A critical player in this domain was Harry Markowitz, who held positions at General Electric and the RAND Corporation, while seeking to develop a generally descriptive approach to representing job shop scheduling systems. The primary obstacle was the incorporation of *time* and *state* characterization in an efficient computational algorithm. Markowitz entered into a working relationship with Alan Rowe, who later based his doctoral dissertation at UCLA on a general simulation model of job shop scheduling enterprises. In the attempt at GE to apply their research experience, Rowe and Markowitz discovered the daunting challenge of *generalizing* a simulation model. Markowitz returned to RAND to pursue his goal of developing a general modeling technique: a simulation programming language that would materialize in SIMSCRIPT; see Kiviat, Villanueva, and Markowitz (1968) and Markowitz (1979). Based on similar experiences in using simulation to solve problems in job shop scheduling at Cornell University, Richard Conway, B. M. Johnson, and William Maxwell formulated the central problems of discrete-event simulation in two seminal papers, Conway (1963) and Conway, Johnson and Maxwell (1959). Many of the problems, and the proposed solution methods, detailed in these papers remain active areas of research and development today.

In the early to mid-1960s, the RAND Corporation was the focal point of many fundamental contributions to the field of computer simulation. Working with Harry Markowitz, Philip Kiviat made major contributions to the development and implementation of SIMSCRIPT II (Kiviat, Villanueva, and Markowitz 1968). Richard Conway and William Maxwell were also frequent visitors to RAND. During this period, George Fishman began his groundbreaking work on statistical methodology for simulation design and analysis. The impetus for this work arose from Fishman's extensive interactions with Kiviat, Pritsker, and others at RAND; see p. 30 of Alexopoulos, Goldsman, and Wilson (2009). Concurrently with the SIMSCRIPT effort, the work of K. D. Tocher and D. G. Owen in the United Kingdom produced the first simulator: the General Simulation Program (GSP) – a set of routines that were common to the application of simulation (Tocher and Owen 1960). At Bell Laboratories and IBM, Geoffrey Gordon was creating the General Purpose Simulation System (GPSS), which had several predecessor names using the same or a similar acronym (Gordon 1981). During the period 1964–1969, Kiviat also worked on the development of GASP II with Alan Pritsker at Arizona State University (Pritsker and Kiviat 1969). The work of Dahl and Nygaard at the Royal Norwegian Computing Center in the design of SIMULA and the subsequent production of SIMULA 67, the first object-oriented programming language, introduced the powerful class concept and a process interaction framework that completed the early conceptual frameworks distinguishing among the simulation programming languages: (i) event scheduling (SIMSCRIPT); (ii) three-phase (GSP); (iii) transaction processing (GPSS); and (iv) process interaction (SIMULA). See Nygaard and Dahl (1981) for a detail account of this seminal work.

1.2 Previous Efforts to Document and Archive the Early History of Computer Simulation

Some preliminary efforts have been made to document the early history of computer simulation as described briefly above. Special emphasis should be given to the following: (a) the archival journal article by Nance (1996) on the history of discrete-event simulation programming languages; and (b) the archival journal article by Nance and Sargent (2002) on the history of computer simulation up to 2002, the fiftieth anniversary of *Operations Research*, one of the flagship publications of the Institute for Operations Research and the Management Sciences (INFORMS). Unique in the simulation literature, Nance (1996) provides key insights into some of the factors driving progress of the field of simulation since its inception by surveying the development of thirty major simulation programming languages over the period 1955–1986. For the special fiftieth-anniversary issue of *Operations Research*, Nance and Sargent (2002) explore the synergy between the fields of computer science, operations research and computer simulation

that has stimulated much of the dramatic growth and development of both fields over the period 1952–2002.

Coedited by David Goldsman (Georgia Tech) and James R. Wilson, the March 2001 issue of *IIE Transactions* honored Alan Pritsker on the occasion of his retirement. The editors coauthored the lead article on Pritsker's career (Wilson and Goldsman 2001) based on their extensive conversations with Pritsker during the last two years of his life. More recently, Christos Alexopoulos (Georgia Tech), Goldsman, and Wilson coedited the book titled *Advancing the Frontiers of Simulation: A Festschrift in Honor of George Samuel Fishman* (Alexopoulos, Goldsman, and Wilson 2009). In the lead article of that book, the editors surveyed Fishman's professional career; and the second article is the transcript of a four-hour interview with Fishman conducted during the period October 25–26, 2007.

In parallel with these efforts to document the early history of simulation, a larger-scale effort has been undertaken to archive this history systematically. In the late 1990s, Robert G. Sargent conceived the idea of a Simulation Archive that would be housed in a major university library as the main repository for the books, papers, and recorded interviews of the pioneers in the field of computer simulation. The Simulation Archive was established in 1998 at the North Carolina State University (NCSU) Libraries with the assistance of James R. Wilson,

http://www.lib.ncsu.edu/specialcollections/simulation/ ;

and an endowment to support this Archive was established in 2007 by Robert G. Sargent with a substantial contribution. The goal is to establish the archive as the premier source for researchers interested in the history and development of the field of simulation. The Simulation Archive is part of the Special Collections Research Center of the NCSU Libraries and receives exceptional support from the administration of the Libraries, including Dr. Susan Nutter, Vice Provost and Director of Libraries. There is an Advisory Committee (consisting of Richard E. Nance, Robert G. Sargent, and James R. Wilson) that works with the Library on management and advancement of the Simulation Archive. Several individuals have donated materials to the Archive and more have committed to donate in the future. Numerous groups and individuals have made financial contributions to the Simulation Archive Endowment, including the following professional organizations: the INFORMS Simulation Society (I-Sim), the Association for Computing Machinery/Special Interest Group on Simulation (ACM/SIGSIM), the American Statistical Association (ASA); the Department of Information Systems and Computing at Brunel University (UK); and the Edward P. Fitts Department of Industrial and Systems Engineering at NCSU. To date, the total amount donated to the endowment exceeds $40,000.

To promote awareness of the activities of the Simulation Archive among the members of the international simulation community, Nance, Goldsman, and Wilson have given two invited ninety-minute presentations on the history of simulation from 1777 to 1982; see Goldsman, Nance and Wilson (2009, 2010). See also Wilson (2011).

2 SUMMARY OF THE CURRENT PROJECT

The project titled "A Retrospective Oral History of Computer Simulation" is jointly sponsored by the National Science Foundation and the Simulation Archive of the North Carolina State University Libraries. The primary objective of the project is to document the emergence of the field of computer simulation since World War II. Our approach is to capture the early history of the field by producing digital videos of interviews with the pioneers of the field whose seminal contributions have had long-lasting impacts on theory and practice, not only in computer simulation but also in the following disciplines: computer science; industrial, manufacturing, and systems engineering; and operations research and the management sciences. This project involves the following activities:

- Identifying those pioneers whose health enables them to participate in the project;
- making the logistical arrangements necessary to produce high-quality digital-video recordings of structured interviews with those pioneers; and

- carrying out the interviews, editing the recordings, and posting those recordings in a universally accessible permanent digital repository. Another key project objective is to provide a template that can be used as an effective guide to performing similar projects for other disciplines, and then documenting the lessons learned from those projects.

The digital videos produced by this project will be made freely available on the Web site of the Simulation Archive hosted by the North Carolina State University Libraries; and the availability of the videos will be widely publicized in the international simulation community and in the broader professional communities that sponsor and participate in the Winter Simulation Conference, including relevant professional societies for women and underrepresented minorities. Faculty members who teach simulation will be encouraged to disseminate these videos to their students and to use the videos in their courses. These videos can also be used effectively in courses on the history of science and technology and in courses on ethnic and gender studies.

So far the following individuals have been interviewed: James O. Henriksen (Wolverine Software); Philip Kiviat (Guerra-Kiviat Inc.); Donald E. Knuth (Stanford University); Harry M. Markowitz (University of California, San Diego and Harry Markowitz Company); Richard E. Nance (ORCA Computer and Virginia Tech); Julian Reitman (Retired); Robert G. Sargent (Syracuse University); Thomas J. Schriber (The University of Michigan); and James R. Wilson (NC State University). Currently plans are being made to expand the list of interviewees over the next several months. The oral presentation of this paper will provide a more detailed summary of the work completed so far and the work planned in the near future.

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