Peter Lewis (1932-2011)
The Early and Middle Years

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Peter’s Early Life

Born in Johannesburg 1932
Father was lawyer and import-export business man
Mother was successful and accomplished artist
Elder brother Ricky and twin sister Pamela
Attended King Edward VIII High School, Johannesburg
Moved to New York 1950
Columbia University: AB degree 1954,
   BS Electronic Engineering 1955
Peter and twin
Sister Pamela,
aged ??
Brother Ricky, Mother, Twin Pamela and Peter
Peter’s Career - Outline

Two phases:

Phase 1 1956-1972 IBM Columbia Research Labs, NYC
   1957 – 6 months - US Army Critical Skills programme
   1960 IBM Research Labs, San Jose, CA

   Moved away from Electronic Engineering towards Statistics

Phase 2 1972-1999 Naval Postgraduate School, Monterey, CA

   Statistics and Operational Research
Phase 1 : IBM NY and San Jose Labs 1955-1972

1955-62
Worked on development of high-speed computers, reliability theory, information retrieval and linguistics

First paper in IBM journal
(1) IBM Journal of Research and Development 1957 (Volume 1)
“An experimental 50- megacycle arithmetic unit”, with three others

Doing multiplication quickly…
50 mc full binary adder, basic circuits and components
Fig 19. The complete system.
Second IBM publication and first statistical paper...

Two parameter lifetime distributions for reliability studies of renewal processes, 1959, IBM Journal of Research and Development with B J (Betty) Flehinger – statistician at IBM NY Lab

A good read today, with all the renewal and distribution concepts employed, such as hazard, survival probability, renewal equation, departures from exponential distribution with quadratic and cubic hazards, truncated Normals, clean mathematics, nice graphs...

\[
f(t) = (\alpha + 2\beta t^2)\exp\{-(\alpha + \beta t^2)\} \quad f(t) = (\alpha + 3\beta t^3)\exp\{-(\alpha + \gamma t^3)\}
\]

Truncated Normal
Second statistical paper and first interest in statistical computing...

Distribution of the Anderson-Darling goodness of fit statistic

Published in ...

Annals of Mathematical Statistics 1961, with 3 pages of tables!

\[ W_n^2 = -n - (n-1)^{-1} \sum_{i=1}^{n} \left( (2i-1) \ln G(X_(i)) + (2(n-1) + 1) \ln(1 - \ln G(X_(i))) \right) \]

Mixture of analytical bounds and Monte Carlo simulations

Complained about prohibitive time for 1m samples, needs more than 6 hours on IBM704

Could only cope with sample sizes 2,3,...,8 but is practically sufficient to reach asymptotic values.

“Inefficiency and impractability of simple Monte Carlo methods…”

Peter had moved to IBM San Jose in 1960 by the time this paper was published, and was becoming more statistical...
1957-62 in San Jose

A period of widening of interests – linguistics, fast Fourier transforms, random number generation, computer failure analysis

Example publication – linguistics

Statistical discrimination of the Synonymy/Antonymy relationship between words

J Assoc. Computing machinery 1967

About how words used in an index lead to the required information from the text. Semantic gap between indexer and searcher. Measures of statistical associations between a group of words in text and index words

IBM Pre-Doctoral Fellowship

Interesting work on computer failure analysis suggested Peter apply for IBM PhD study…
1962-64  IBM Pre-Doctoral Fellowship,
Imperial College, London, supervisor David Cox
Defining event in Peter’s statistical life

Topic: Point Processes: Modelling and analysis of computer failure sequences. Thesis led to
1 Royal Statistical Society ‘Read paper’ - Branching Poisson Process
1 Royal Statistical Society Series B paper – Non-homogeneous BPP
2 Journal of Applied Probability papers – Maintenance implications
1 Advances in Applied Probability paper – Various properties of BPP

Also, co-authored Methuen Monograph with David Cox,
‘Statistical analysis of series of events’ (price $4)
Also, produced associated software package SASE
Peter’s Branching Poisson Process,
from my ‘retirement symposium talk Peter in 1999

Finite renewal processes, \( F(y) \) interval
Number \( \sin \) each

A very complicated superposition problem!

Elegantly developed...

Motivated by computer failure modelling
(main failure Poisson, then repeats)

Motivated by D.V.I./Earthquake, A.H./Neurophysiology)
Branching Poisson Processes

The motivation came from Peter’s IBM work on computer reliability and failure sequences with Betty Flehinger and consideration as to why their data did not accord with Poisson process properties.

The JRSS ’Read Paper’ is a delightful example model-based statistical analysis; the mathematics of the modelling is very clean and elegant in a non-fussy way.

I particularly like the inter-failure time distribution result with survivor function:

\[ R_r(t) = \frac{1+ E(S)R_y(t)}{1+ E(S)} \exp \left\{ -\alpha t - \alpha E(S) \int_0^t R_y(u)du \right\} \]

The log tail form of this survivor function is:

\[ -\log \left\{ 1 + E(S) \right\} - \alpha E(S)E(Y) - \alpha t \]

Thus allowing the basic failure rate to be estimated from the right-hand tail.

There is a wonderful discussion to this paper, but which was somewhat daunting to a pre-doctoral student like myself in 1965. I did write a JRSS Series B paper in 1971 on the initial conditions of the process at an arbitrary failure, eg the number of subsidiary sequences running, their remaining failures, etc.
Returned from London to new IBM Thomas J Watson Research Center, Yorktown Heights, NY

Continued developing and widening interests -
Fast Fourier transforms, with Jim Cooley and Pete Welch
Random number generation – LLRandom (Lewis-Learmouth)
Computer modelling: queuing, buffer storage, cyclic queues, paging, exception data
Sampling distributions by simulation, quantile estimation

London beckoned again…

1968-70 Post-doctoral NIH Fellowship, on leave from IBM, at Imperial College London, working on above topics, and multi-type point processes,…(Berkeley Symposium paper with David Cox)

I spent a memorable year 1970-71 at IBM TJW Research Center

1971 - Organized Point Process Conference at IBM Yorktown Heights…
David Cox gave very early introduction to proportional hazards modelling.

Alan Hawkes introduced ‘mutually exciting point processes’, there after called ‘Hawkes processes’.
Peter moved to Naval Postgraduate School, Monterey 1972

Many Parzen, Maurice Bartlett, Peter, David Cox, Klaus Matthes, David Vere-0Jones, Joe Gani
Mid 70’s – 80’s Naval Postgraduate School, Monterey

Much work on time series modelling moving away in various directions from standard arma models, collaborating with a large number of people

The starting point was the Gaver-Lewis gamma distributed linear first order autoregressive model

This was a eureka moment for Don Gaver ...
and here is the Gaver eureka moment …
The hand-writing may be familiar…

Time series – ‘eureka paper’ - Gamma AR(1) process, Gaver-Lewis produced about 1970, published AAP 975

reason for delay?

**gamma case**

\[ \phi_k(\theta) = \left[ \rho + (1 - \rho) \frac{\lambda}{\lambda - \theta} \right]^k \]

**self-decomposable**

**The Gamma-Autoregressive Process, GAR(1)**

(Gaver & Lewis - started 1975; published AAP, 1980)

Start with regular linear, additive, constant coefficient time series model (stochastic diff. equation)

\[ X_n = \rho X_{n-1} + E_n, \quad n = 0, \pm 1, \pm 2, \ldots \]

where \( \rho \) constant; \( E_n \) i.i.d (no change mean or variance)

If \( |\rho| < 1 \) and \( E_n \) normal \( (0, \sigma^2) \), then \( X_n \) is normal, autoregressive process mean \( 0 \), \( \sigma_n = \sigma^2 / (1 - \rho^2) \)

**Question**: If specify marginal distribution of \( X_n \) (assumed stationary), does \( E_n \) sequence exist??

e.g. exponential.

Since \( X_{n-1} \) and \( E_n \) \( \Rightarrow \) independent,

\[ \Phi_X(s) = \mathbb{E}(e^{-sX_n}) = \Phi_{X_n}(s) \cdot \Phi_{X_n}(s) \]

or \[ \Phi_E(s) = \Phi_X(s) / \Phi_X(0) \] ??

Can show that if \( X_n \) is Gamma distributed, then there exists an \( E_n \) sequence.

(Type I or self-decomposable - all \( \theta < \lambda \))
A working Gaver-Lewis ++ non-Gaussian lunch

Don Gaver, Pat Jacobs, Peter, Luis Uribe at ‘The Clock’
A eureka moment for me was realizing that this intractable Laplace transform was actually invertible by connecting the Gamma AR(1) to a particular shot noise process.

An inverted form of

\[ \phi_{\varepsilon}(\theta) = \left[ \rho + (1 - \rho) \frac{\lambda}{\lambda - \theta} \right]^k \]

by considering a particular shot-noise process with equi-spaced sampling, gave the representation

\[ \varepsilon_n = \sum_{r=1}^{N} \rho^{U_r} Y_r \]

where

- \( N \sim \text{Poisson}\{k \log(1/\rho)\} \)
- \( U_r \sim \text{IID uniform}(0,1) \)
- \( Y_r \sim \text{IID exp}(\lambda) \)
Mid 70’s – 80’s NPS\textsubscript{cntd}

Developments of time series models

The realization was that the additivity/linearity assumption could be replaced by an operation appropriate to the desired marginal distribution

Discrete-variate distribution ARMA models – Pat Jacobs, JRSS, AAP papers

Exponential-variate distribution ARMA models, residual analysis – AJL, JRSS paper, joint JRSS read paper, JAP papers

Residual analysis and reversed residuals - ISIR paper, ?

Minification and product AR models – Eddie McKenzie, JAP, Management Science paper

During this period, Peter worked on several other topics, e.g. simulation of non-homogeneous Poisson processes, density function estimation, random number generation
With Eddie Mckenzie from Strathclyde University Scotland

Worked with Peter for two years at NPS, mainly on discrete-valued time series, involving mixture and minification operations replacing linearity
A talk from the ‘Non-Normal Time Series era

A RESIDUAL ANALYSIS

for

NON-NORMAL TIME-SERIES

with

Autoregressive correlation structure

P.A.W. Lewis

Naval PG School
Monterey, Cal.
Time Series Workshop, Edinburgh, 1989
At Glasgow University after giving a talk - Jonathon Tawn, Peter, Howell Tong, Eddie McKenzie, ? - 1989
Peter’s Work in Simulation Methodology

Simulation was a strong statistical theme in Peter’s research contributions, starting with his first paper on the Anderson-Darling statistics. He was highly regarded in the OR world for this work. The main themes were:

Random number generation (LLRANDOM)

Dependent random sequences in different distributions, often with autoregressive dependency (deriving from work in various non-Gaussian time series models)

Quantile estimation for dependent sequences

Regenerative simulation

Output analysis of simulation

A few comments on the last two, but first…
Simulated relaxation...

John Orava, Luise Uribe, Kevin Wood, Peter
Regenerative Simulation

Peter worked on this topic in the 1980’s with: Donald Iglehart and several others

Regenerative simulation applies to simulating stochastic processes in which there are points of ‘regeneration’ in the sense that generations or cycles (sets of outcome variables) of the process are IID, and it exploits this property – one such is the busy period of a simple queue and the … Branching Poisson Process

To my knowledge Peter never simulated this process !!

Typical $k$-th busy period is of length $\tau_k$, waiting times are $X_1, X_2, \ldots, X_{\tau_k}$

Need to estimate expected waiting time $\mu = E(X)$

From one cycle this can be by $\hat{\mu} = \tau_k^{-1} \sum_{i=1}^{\tau_k} X_i \equiv \tau_k^{-1} Y_k$

From $n$ cycles might use $\bar{\tau}_k^{-1} \bar{Y}_k$, the numerator and denominator cycle averages

How to achieve variance reduction of this estimate by ‘internal controls’?

$$\hat{\mu} = \frac{n^{-1} \sum_{k=1}^{n} [Y_k + \beta (C_k - E(C_k))]}{\bar{\tau}(n)}$$

$C_k$ control variable of known mean highly correlated with $Y_k - \mu \tau_k$
Interest included the simulation estimation of small sample and large sample asymptotic mean and variance results

\[
E(r_n) = a_0 + \frac{a_1}{n} + \frac{a_2}{n^2} + \frac{a_3}{n^{3/2}} \quad \text{var}(r_n) = b_0 + \frac{b_1}{n^{3/2}} + \frac{b_2}{n^2} + \frac{b_3}{n^{5/2}}
\]

Collaborators: Phil Heidelberger, John Orav, Luis Uribe, Kevin Wood
At Peter’s retirement Symposium, NPS, March 1999
With good friend Manny Parzen, Point Lobos, retirement symposium, 1999
Peter A.W. Lewis Receives the 2011 Lifetime Professional Achievement Award, INFORMS Simulation Society

Extracts…

The *Lifetime Professional Achievement Award* is the highest honor given by the INFORMS Simulation Society. The award recognizes major contributions to the field of *simulation* that are sustained over most of a professional career, with the critical consideration being the total impact of these contributions on the field…

...Peter's work on *simulation theory and methodology* encompassed the areas of *input modeling* (time-series models and non-stationary point processes), *random-number generation*, *variance-reduction techniques*, and *output-data analysis* (regenerative method and quantile estimation).

...serving on the Winter Simulation Conference Board of Directors as ASA's representative from 1986 to 1989