Abstracts

From Recent Papers by IBM Authors

Algorithm for Diagonalization of Large Matrices, R. K. Nesbet, *Journal of Chemical Physics* **43**, No. 1, 311–312 (July 1, 1965). This note describes a computational algorithm intended to be efficient for very large matrices. Several properties make the method advantageous for large n: the time required to compute a single eigenvector is proportional to n^2, not n^3, as in most standard diagonalization methods; the unit process requires only one row of H at a time, facilitating buffered block transfer of very large matrices ($n > 250$) from auxiliary memory in a computer system; the eigenvalue convergence is second order; and the lowest eigenvalue converges monotonically. The proposed method combines the second-order matrix diagonalization algorithm of Lowdin with the classical iterative method for solving linear equations of Seidel, used by Boys in a first-order matrix diagonalization algorithm.

Analysis of Real Time Multiprogramming, Wei Chang and Donald J. Wong, *Journal of the Association for Computing Machinery* **12**, No. 4, 581–588 (October 1965). The problems associated with a real time message processing system in the multiprogramming environment are described. The basic philosophy of multiprogramming is compared with that of sequential processing in order to put the concepts in their proper perspective. A mathematical model was developed based on the theory of priority queues. The queue size and its variability within the CPU Ready List, the Real Time List and the Non-Real Time List can then be computed with the enclosed formulation. In turn, the core requirement for the central processor can be determined.

Another Criterion for Significance, Arthur J. Sable, *The Philosophical Forum* **22**, 33–42 (1964–1965). A formulation, Criterion M, is proposed for a test of significance of sentences. Criterion M is based on a logical relationship of significant sentences to observation-sentences, and overcomes difficulties of earlier formulations which satisfy this empiricist condition. Criterion M is subject to qualifications of finiteness which do not limit its applicability to a large class of statements of natural languages.

Application of Adaptive Threshold Elements to the Recognition of Acoustic-Phonetic States, James E. Dammann, *The Journal of the Acoustical Society of America* **38**, No. 2, 213–223 (August 1965). The relation of acoustic-phonetic states to the problem of speech recognition is discussed. It is suggested that a first step toward understanding the dynamics of the speech signal could be made by recognizing a small number of acoustic phonetic classes. Adaptive threshold elements are proposed as a means of recognizing these classes and a method of utilizing the adaptive threshold elements in a decision procedure is presented. The means employed to gather the data representing the classes consists essentially of taking amplitude samples from a bank of 15 filters at 10-msec intervals. Samples obtained in this manner are used as input for the adaptive-decision procedure, which is simulated in a general-purpose computer. Samples representative of each class are used to train the adaptive-decision procedure, and the capability to generalize to new samples is observed. For one speaker, generalization results of 92%-correct sample classification were achieved, and generalization from one speaker to another was demonstrated. It further was shown that the selection of an output code can significantly affect the generalization, and that sequencesof recognized samples can represent dynamic changes through words.

Approximate Controllability for Distributed Linear Systems, W. L. Miranker, *Journal of Mathematical Analysis and Applications* **10**, No. 2, 378–387 (April 1965). The problem of controllability of distributed linear systems is described in terms of the flow of convex sets in function space. Controllability is then characterized in terms of the separability of the convex sets by a hyperplane. Since for flows governed by partial differential equations, the set of non-reachable points in the function space may be everywhere dense, conditions for approximate control, wherein the system is required only to come into a given neighborhood of a target state, are established.

An Approximation Technique for Suboptimal Control, R. C. Durbeck, *IEEE Transactions on Automatic Control* AC—10, No. 2, 144–149 (April 1965). This paper presents a new technique for generating an approximation to the minimum performance functional V for optimization of dynamic systems. Convergence of the technique is shown and the results from two example systems are given. The resultant approximation V is shown to be useful over a significant region in state space for (1) generating a near optimal control law, (2) determining regions of stability, and (3) defining useful bounds associated with the system performance.

Automatic Fact Retrieval, W. S. Cooper, *Science Journal* 1, No. 4, 81–86 (June 1965). In recent years much attention has been directed to the possibility of using electronic computers for information retrieval. By the term "information retrieval" is meant the process of retrieving a needed piece of information from a large fund of mostly irrelevant information. In less abstract terms, it is the process a scientist or other scholar must perform when he has to scan through a stack of books and articles before he comes at last upon the information which is of interest to him. The conventional methods of searching the literature are often extremely tedious and time consuming. With the advent of the large scale digital computer, the question has naturally arisen whether it might be possible to automate some or even all of the conventional retrieval processes.

Burst Measurements in the Time Domain, W. W. Lang, *Proceedings of the Fifth International Congress on Acoustics*, Liege, Belgium, J66-1–J66-4 (September 1965). A study has been made to identify the parameters that are most appropriate for characterizing burst-like events. A set of such parameters has been defined. Methods for measuring the values of these parameters in the time domain with three different types of instrumentation have been developed.

A Comparison of Block and Recurrent Codes for the Correction of Independent Errors, C. V. Freiman with J. P. Robinson, *IEEE Transactions* IT II, No. 3, 445–449 (July 1965). Expressions for mean time to uncorrectable errors are rigorously derived for ϵ-tuple error-correcting block codes and Type A e-tuple error-correcting recurrent codes when used in a memoryless binary symmetric channel with small probability of bit error p. It is shown that, if these codes are to perform equally well independent of p, it must be true that $e = \epsilon$ and

$$(e + 1) \cdot \binom{n_A - 1}{e} = \binom{n_B - 1}{e}$$

where n_B is the block length of the block code and n_A is the error span of the recurrent code. Optimum single error-correcting block and recurrent codes are then compared in detail. It is shown that for equivalent performance the recurrent code requires slightly more redundancy, but significantly less storage in the coding circuitry as determined by n_A and n_B.

Computer-Assisted Cam Manufacture, J. J. Harvey, *Tool & Manufacturing Engineer* 55, No. 2, 76–77 (August 1965). Master and low-volume cams are produced to ± 0.0002 in. radial tolerance in less time and for less cost by utilizing a computer and a numerically controlled jig bore. Polar coordinate cam data is processed through the computer. The computer program interpolates the given data, if desired, to reduce the increment between movements, calculates movements along dwells, and converts input data to rectangular coordinate output. The output in the form of punched tape is used to produce the cam on the numerically controlled jig bore.

Computer Automated X-Ray Stress Analysis—A Versatile Test Method, G. Koves, *Annals of Reliability and Maintainability* **4,** 597–603 (1965). This paper describes an x-ray diffraction test method in which both the measurement and evaluation steps are highly automated, making this high-precision technique available as a practical quality control tool. The evaluation procedure is completely computer automated using a FORTRAN program and an IBM 7090 Data Processing System. The test method combines the depth and accuracy of the x-ray technique with the high speed and simplicity essential for a quality control procedure.

A Computer-Oriented System, L. F. Knappe, *Mechanical Engineering* **87,** No. 5, 35–40 (May 1965). This article describes the development of an engineer-computer mechanical design system called COMMEND (Computer-Aided Mechanical Engineering Design). The initial system is restricted to the design of planar or equivalent planar mechanisms and implemented on presently available computer equipment. The article discusses the problems encountered in utilizing a computer in the mechanical design process and the system approach taken for this project. Design system programs are discussed along with examples. Anticipated benefits of the design system are also reviewed.

Decision Making in Incompletely Known Stochastic Systems, J. Raviv, *International Journal of Engineering Science* **3,** No. 2, 119–140 (July 1965). This paper is a study of decision making in a discrete-state discrete-time system whose state transitions constitute a Markov chain with unknown stationary transition matrix P. The states of the system cannot be observed. The decision at each stage is based on observables whose conditional probability distribution given the state of the system is known. We consider a class of problems in which the successive observations can be employed to form estimates of P, with the estimate at time n, $n = 0, 1, 2 \cdots$, then used as a basis for making a decision at time n. The estimates and the corresponding decisions must have the property that as $n \rightarrow \infty$, the decision based on the estimate of P tends to the optimal decision rule which would be used throughout if P were known.

Design with Computers, M. A. Howard, *Mechanical Engineering* **87,** No. 5, 31–34 (May 1965). A computer program concept is described that enables the engineer-designer to utilize a computer in performance of repetitive design and analysis calculations for mechanical components. The program logic is designed to accept component functional parameters and/or optional physical size parameters or operating conditions to provide information for part drawing specifications, quality assurance information and analysis data for evaluating the design.

Design Considerations for a 25-nsec Tunnel Diode Memory, D. J. Crawford, R. L. Moore, J. A. Parisi, J. K. Picciano, and W. D. Pricer, *Computer Design* **4,** No. 9, 30–42 (September 1965). The design factors for a practical ultra-high speed "scratch pad" memory are described. Information is stored in an array of tunnel diodes interconnected with driving and sensing circuits in a manner to specifically minimize cycle time. The design features modular construction of both the storage array and the associated circuits, practical component tolerances, and compact construction. A fully populated system now under construction contains 64 words of 48 bits each complete with address circuits and I/O data circuits. The memory is designed to operate at a 25-nsec cycle time. Special features of interest are miniature printed circuit transformer construction, high-speed driving techniques, and rapid regeneration of interrogated information.

Dispersion Analysis as Applied to Speech Spectra, J. E. Dammann, *Proceedings of the Fifth International Congress on Acoustics,* Liege, Belgium, A54-1–A54-4 (September 1965). In attempts to determine the structure of the speech signal, it is difficult for the analyst to view the situation from a purely objective point of view. That is, he ordinarily must use subjective notions of the structure of language phenomena. The dispersion analysis method is an attempt to expose some of the speech structure without making any *a priori* assumptions about that structure. The data is simply taken and transformed by a general method called dispersion analysis. The results presented in the paper are the first from the application of dispersion analysis to speech and must be regarded as only indications of what further study may show. The dispersion analysis method does not appear to provide one with a "God's truth" picture of what is happening in speech, but it does appear to provide one with some interesting views of its phonetic character and dynamic aspects.

Enumeration of Strongly Connected Sequential Machines, C. E. Radke, *Information and Control* **8,** No. 4, 377–389 (August 1965). Recently, attention has been given to the problem of counting the number of equivalence classes of finite automata. The enumeration problem for strongly connected sequential machines has remained unsolved. This paper develops a recursive solution from which the number of strongly connected, complete sequential machines can be determined for an arbitrary state set, input set, and output set.

Generalized Commuting Properties of Measure Preserving Transformations, R. L. Adler, *Transactions of the American Mathematical Society* **115,** No. 3, 1–13 (March 1965). In this paper we discuss the following: Let **G** be the group of measure preserving transformations on a measure space $(X, \mathfrak{B}, m)$. Associated with a given $T \in \mathbf{G}$ is a sequence $C_n(T)$, $n = 0, 1, 2, \cdots$ of subsets of **G** defined inductively by

$$C_0(T) = \{S : S \in \mathbf{G},\ S = I \text{ a.e.}\}$$

$$C_n(T) = \{S : S \in \mathbf{G},\ STS^{-1}T^{-1} \in C_{n-1}(T)\}.$$

It is clear $C_n(T) C C_{n+1}(T)$. If there exists N such that $C_N(T) = C_{N+1}(T)$ then $C_n(T) = C_{n+1}(T)$ for all $n \geq N$; and, in this case, we define $N(T) = \min\{N: C_N(T) = C_{N+1}(T)\}$, otherwise we set $N(T) = \infty$. $N(T)$ is a spatial isomorphism invariant for measure preserving transformations. $N(T)$ is computed for transformations with pure point spectrum and Anzai's skew product transformations.

Improper Solutions Under Existence Assumptions: An Example, J. H. Eaton, *IEEE Transactions on Automatic Control* AC-10, No. 2, 186–189, (April 1965). A pursuit problem is considered in which a pursuer X and target Y are points in an n-dimensional Euclidean space E^n. The pursuer is assumed to have knowledge of the control (and hence trajectory) to be used by the target and is to choose a control to minimize the pursuit time. The target, wishing to delay interception as long as possible, desires to choose a control which maximizes the pursuit time. It is shown that if the target assumes the existence of an optimal control (i.e., a control for which the least upper bound of the pursuit time is attained), he can be lead to a choice of control which will result in an interception in less time than if he applied no control at all.

Mathematische Darstellung der Wirkungsweise von Instrumenten für die Trägheits-Navigation (Mathematical Models of Inertial Sensors), Friedrich G. Unger, *Elektrotechnische Zeitschrift* **86,** No. 16, 534–539 (August 6, 1965). Mathematical models of inertial sensors are differential equations, transfer functions, block diagrams and the combination of a vector and a matrix. These models are derived for gyros and accelerometers, including the important error sources. The inputs to inertial sensors are the vector of linear acceleration **a** and the vector of angular rate **ω**. These two vectors can be combined into one vector **X**. The output of the sensors is derived as a function of these input vectors.

Optimal Multiplier Trees of Carry-Save Adders with Mixed Delay, C. V. Freiman and J. D. Ullman, *Proceedings of IFIP Congress* **65**, New York, (May 1965). In a recent publication, Wallace [1964] has discussed the use of a large tree of carry-save adders in order to achieve a high-speed multiplier in which no intermediate sums are stored. Smaller trees have also been used in combination with stored intermediate sums in machines such as the IBM 7030. In all work reported thus far, it has been tacitly assumed that the maximum delay is the same for all input-output pairs. Many efficient binary adders exist which are not of this form, and the fastest basic adders often cannot be of this form because of limitations on the fan power of the basic logic gates. In this paper we first show how integer programming may be used to design optimal multiplier trees of carry-save adders with arbitrary delay profile. Direct constructive algorithms requiring no integer programming are then presented for two important special cases. Attention is next focused on the case where several passes through the tree are required per multiplication and intermediate sums are stored. Again, both general and specific methods are presented for an optimal multiplier based on minimum storage time. All results presented are directly expandable to adders with any number of homogeneous inputs.

Optimal Programming of Lot Sizes, Inventory, and Labor Allocations, Bernard P. Dzielinski and R. E. Gomory, *Management Science* **11**, No. 9, 874–890 (July 1965). The economic lot size programming problem as studied originally by A. S. Manne and later by B. P. Dzielinski, C. T. Baker, and A. S. Manne, is the problem of making economic lot size, inventory and work force decisions in a multi-production process. When several thousand distinct items are involved, the large number of equations that result from the linear programming formulation makes computation infeasible. Also, a large number of variables are involved because of inclusion of alternative set-up sequences for each item. In this paper, the application of the Dantzig and Wolfe decomposition principle and a method for creating alternative set-up sequences as they are needed by means of a computation of the Wagner and Whitin type is described as a method for overcoming the computational difficulty. A digital computer program has been developed using these methods. The results of some experiments where production was planned for a large number of distinct items are described.

Optimizing Magnetostrictive Delay Lines, V. Ramakrishna, *Electro-Technology* **76**, No. 2, 45–47 (August 1965). One way to store information for later use is to slow down the signal which contains it. The magnetostrictive delay line, in effect, slows down an electrical signal travelling at the speed of light to the speed of sound. Milliseconds later, the input is available for further processing or for comparison. But the accuracy and strength of the output depend on the dimensions and materials of the delay line. The author describes an analytical technique for optimizing these parameters.

Parameter Estimation for a Generalized Gamma Distribution, E. W. Stacy and G. A. Mihram*, *Technometrics* **7**, No. 3, 349–358 (August 1965). It is fairly commonplace in reliability analyses to encounter data which is incompatible with the exponential, Weibull, and other familiar probability models. Such data motivates research to enlarge the group of probability distributions which are useful to the reliability analyst. In this paper, we examine a three-parameter generalization of the gamma distribution and derive parameter estimation techniques for that distribution. Those techniques, in the general case, depend upon method-of-moments considerations which lead to simultaneous equations for which closed form solutions are not available. Graphic solution is proposed and aids to the computations are provided. Major concepts in the paper are summarized by means of a numerical example. Details are given for the special case in which only the scale parameter is unknown. Three unbiased estimators for that parameter are derived along with their variance formulas. Minimum variance considerations are discussed by application of the Cramér-Rao Theorem.

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PL/I: A New Programming Language, R. A. Sibley, *ACM Proceedings of the 20th National Conference*, 543–563 (August 1965). After a discussion of the procedures and motivations that have, to date, accompanied its development, a survey of the characteristic features of PL/I, a new programming language, will be presented. Following a section where primary implementation considerations are explored, an experimental implementation of a PL/I compiler is covered in some detail. This last discussion includes a brief description of a special-purpose programming system that was used in this experimental work.

Preemptive Priority Queues, Wei Chang, *Operations Research* **13**, No. 5, 820–827 (September–October 1965). Customers of different priorities arrive at a counter in accordance with a Poisson process. The customers are served by a single server in order of priority and for each priority in order of arrival. Preemptive discipline is assumed. Three service policies are considered: (1) preemptive-resume, (2) preemptive-repeat-identical, and (3) preemptive-repeat-different. The time-dependent solutions for these priority systems are very complicated. However, the problem can be simplified in the case of stationary solutions. In this paper, a step-by-step method is proposed to find the stationary distributions of the queue sizes, the waiting times, and the busy periods of each priority class.

On a Problem Concerning a Central Storage Device Served by Multiple Terminals, M. V. Menon, *Journal of the Association for Computing Machinery* **12**, No. 3, 350–355 (July 1965). A storage or processing device with a fixed number of cells is considered. If a chance-mechanism selects which of M persons is to transmit an element of message to the device, the probability is found that the device will be filled without a complete message having been introduced into it. This probability should be useful in determining the "optimum" number of persons who can use the device. The problem is treated as one in an M-dimensional random walk.

Some Results on Tests for Poisson Processes, P. A. W. Lewis, *Biometrika* **52**, Parts 1 and 2, 67–77 (June 1965). It is shown that a test proposed by Barnard for Poisson processes, using certain distribution-free statistics, is not consistent against renewal alternatives. However, empirical evidence is given which suggests that a modification of this test due to Durbin results in relatively powerful tests of the Poisson hypothesis. A simple test based on Durbin's modification is described, and its asymptotic relative efficiency with respect to the asymptotically most powerful test against the alternative of a renewal process with gamma-distributed intervals is given.

Secondary Key Retrieval Using an IBM 7090-1301 System, A. D. Lin and D. R. Davis, *Communications of the Association for Computing Machinery* **8**, No. 4, 243–246 (April, 1965). The secondary key retrieval method involves the preparation of secondary storage lists from primary data records. Search requests are satisfied by logical operations on appropriate lists, producing a complete set of addresses of primary records relevant to the request. Experimental results are presented and a comparative analysis is given.

Self-Correcting Memory, G. C. Randa and C. V. McNeil, *Electronic Design* **13**, No. 18, 28–31 (August 30, 1965). A memory system with self-correcting ability, designed for a digital-guidance computer, achieved a reliability factor of 0.999. This reliability has been made possible by combining the self-correcting feature with the duplex, or redundant, concept. The design is flexible enough to permit operation either in the duplex (redundant) mode, or in the serial (simplex) mode, depending upon the nature of the mission.

Shrinking the Man-Computer Interface, W. F. Hubbarth, *Control Engineering* **12,** No. 8, 63–66 (August 1965). As space systems evolve, increased utilization of a general purpose computer is required to meet mission objectives. The digital computer is becoming the prime data handling means and will be used for every phase of a space mission as the basis of navigation, guidance, system monitoring, crew monitoring, and scientific data processing. Effective utilization of this general purpose system requires that the crew members be provided with an appropriate interface to accomplish the aims of the mission. Design concepts are presented for the man/computer interface with emphasis on key parameters. Examples of this interface are given.

A Small Computer for the Direct Processing of FORTRAN Statements, A. J. Melbourne and J. M. Pugmire, *The Computer Journal* **8,** No. 1, 24–27 (April 1965). A small computer with a microprogrammed FORTRAN compiler is described. A comparison is made with a conventional computer of similar speed which uses a software compiler.

Solution of the Equation for Wave Propagation in Layered Slabs with Complex Dielectric Constants, J. W. Cooley and F. Stern, *IBM Journal of Research and Development* **9,** 405–411 (Sept.–Nov. 1965). A numerical procedure for solving the eigenvalue equation $u'' = [V(x) - E]u$, where $V(x)$ is complex, is described. The number of eigenvalues and their approximate location can be determined by contour integration in the complex trial eigenvalue plane. Some general features of the solutions and an example are given.

On the Solution Set of a Linear System with Inaccurate Coefficients, W. Oettli, *SIAM Journal, Series B, Numerical Analysis* **2,** No. 1, 115–118 (1965). The variation of the solution of the linear $(n \times n)$-system $Ax = b$ is studied when the coefficients a_{ij} and right-hand sides b_i are assigned intervals of variation of the length $2\triangle a_{ij}$ and $2\triangle b_i$, respectively.

Statistical Method of Analyzing Long-Term Tropospheric Loss, Michael Schilder*, *Electrical Communication* **40,** 99–108 (1965). Weather variables that cause signal-strength variation on tropospheric-scatter paths are analyzed for the purpose of developing a prediction equation applicable to all paths. This analysis indicates that the general refractive index is not the only weather variable that affects signal strength, and possibly it is not even the most significant. The results indicate that the height at which the pressure is 500 millibars is a better predictor of signal strength. This study also shows that substantial and unexplained variations still exist among prediction equations for different paths. If more-careful methods of analysis can isolate the weather factor that causes signal strength to change, a universal prediction equation may emerge.

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Symbolic Computation of f and g Series by Computer, P. Sconzo, A. R. LeSchack, and R. Tobey, *Astronomical Journal* **70,** No. 4, 269–271 (May 1956). A digital computer program, capable of generating and manipulating symbolic mathematical expressions for the coefficients of the f and g series of Keplerian motion, is discussed. Terms up to the 23rd order are given as polynomials in the local invariants μ, σ, and ϵ used by Stumpff.

A Uniqueness Theorem for the Displacement Boundary-Value Problem of Linear Elastodynamics, by M. E. Gurtin* and R. A. Toupin, *Quarterly of Applied Mathematics* **23,** No. 1, 79–81 (April 1965). The classical uniqueness theorem for the displacement problem of linear elastodynamics rests on the assumption that the elasticity tensor is positive semi-definite. In this paper it is shown that uniqueness follows from the weaker condition that the acoustic tensor for each direction of propagation be positive semi-definite.

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