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RC 7555 (#32560) 2/27/79
Mathematics 46 pages

New Fast Algorithms for Matrix Operations

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Typed By Candi Brown (VP.2297)

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Abstract: A new technique of trilinear operations of aggregating, uniting and canceling is introduced and applied to constructing fast linear non-commutative algorithms for matrix multiplication. The result is an asymptotic improvement of Strassen's famous algorithms for matrix operations.

Key words: fast algorithms, complexity of computation, arithmetic complexity, linear algebraic problems, matrix multiplication, bilinear forms, trilinear form.

RC 7516 (#32506) 2/20/79
Computer Science 21 pages

A NATURAL LANGUAGE PARSER WITH STATISTICAL APPLICATIONS

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ABSTRACT:

A syntactic analyzer for natural language processing will be described. The analyzer is based on Controlled Partition Grammars which are used in a bottom up, depth first parsing algorithm with the capability to collect statistics on all syntactic levels, including the function of lexical items based on the syntactic structures they occur in. The analyzer has been designed as an additional information source for the continuous speech recognition system at IBM which uses probabilistic methods with information theoretic decoding procedures. The domain of the current system is a naturally created corpus of about 1.8 million words with "unrestricted" use of English syntax.

KEYWORDS:

Natural language processing, continuous speech recognition, syntactic analyzer, parsing algorithm, controlled partition grammars, statistics collection, structural statistics.

RC 7519 (#32481) 2/15/79
Computer Science 10 pages

Towards a Cognitive Theory of Reference*

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Abstract: Two experiments examined the creation of name expressions for reference, with specific regard to Olson's (1970) 'cognitive theory of semantics'. In the first experiment subjects were merely asked to make up names for each of a series of abstract symbols embedded in displays. In the second experiment, subjects were asked to make up names in order to verbally distinguish between symbols in each display. Only under the second procedure were the predictions of Olson's analysis confirmed. These results suggest that naming, and therefore reference in general, cannot be comprehensively treated in a theory that fails to explicitly deal with referential purposes. Implications of this conclusion for Olson's theory and for further elaborations of a cognitive analysis of naming and reference were raised.

RC 7527 (#32222) 1/9/79
7 pages

A NOTE ON PATTERN-MATCHING: WHERE DO YOU FIND THE MATCH TO AN EMPTY ARRAY?

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Abstract

The question in the title is answered, and the answer justified by a derivation and use in two applications, string partitioning and string editing. Some implications for APL language extensions are also noted.

RJ 2471 (#32358) 2/16/79
Computer Science 13 pages

NORMAL FORMS AND RELATIONAL DATABASE OPERATORS

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RC 7505 (#32407) 2/5/79
Mathematics 15 pages

ON MATROID INTERSECTIONS

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Typed by Angela Vassallo

ABSTRACT: This paper exploits and extends results of Edmonds, Cunningham, Cruse and McDiarmid on matroid intersections. Let r_1 and r_2 be rank functions of two matroids defined on the same set E . For every $S \subseteq E$, let $r_{12}(S)$ be the largest cardinality of a subset of S independent in both matroids, $0 \leq k \leq r_{12}(E)-1$. It is shown that, if C is nonnegative and integral, there is a $y: 2^E \rightarrow \mathbb{Z}^+$ which maximizes $\sum_S (k-r_{12}(E-S))y(S)$ and $\sum_S (k+1-r_{12}(E-S))y(S)$, subject to $y \geq 0$, $\forall j \in E, \sum_{S \ni j} y(S) \leq C_j$.

RC 7510 (#32456) 2/12/79
Mathematics 7 pages

Accelerating the Computation of Averages for Josephson Junctions

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Abstract: An extrapolation method is introduced to accelerate the computation of averages characterizing the voltage response in the current driven Josephson junction. The method exploits the relationship between the voltage to be calculated and the periodicity in the phase of the electron wave function. Error estimates and computations show the accelerative method to be effective.

* Under the auspices of a student interaction program agreement with SUNY at Purchase.

RC 7533 (#32557) 2/26/79
Computer Science 58 pages

Natural Strategies in Naming

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Abstract: Ten subjects rendered names for each of 168 novel entities. The entities were quite varied, differing widely along several dimensions: some were textual, some graphic; some were concrete, some abstract; some appeared in homogeneous reference sets, some in heterogeneous sets, etc. Naming 'strategies' in this task situation were assessed with several dependent measures: (1) the structural form of the name expression (compound noun, lexically modified noun, etc.), (2) the content analysis of the name (i.e., into morphological patterns that directly convey content properties of referents), (3) various statistical measures (number of lexical constituents, syllables, etc.), and (4) comments and ratings elicited from participants. Several general strategies were induced. In addition, it was found that naming strategies differ systematically as a function of the referent type. These results encourage the possibility that modern contextualist analyses of word formation and neologism may provide an empirical foundation for non-speculative studies in this area.

RC 7542 (#32487) 2/15/79
Computer Science 45 pages

DEVELOPMENT OF AN APL STANDARD

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RC 7541 (#32620) 3/6/79
32 pages

Experiments on Composing Letters: Some Facts, Some Myths, and Some Observations

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Abstract: A new experimental methodology was developed to study writing and other methods of composition. Participants are given letter-assignments to compose, and they are videotaped in a laboratory setting while writing, dictating, speaking, or typing them. Composition times are analyzed into generating, reviewing, and planning. The first section of this chapter summarizes results from many experiments. Of significance, planning time is two-thirds of composition time, regardless of method or letter complexity. The second section of this chapter contains several theoretical considerations about composition.

RC 7546 (#32637) 3/8/79
Computer Science 5 pages

ECONOMIC CONSIDERATIONS IN THE DESIGN OF THE
SOFASIM (SOCIETY OF ACTUARIES) SIMULATOR

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ABSTRACT: SOFASIM is a simulation model of a life insurance company. It includes a detailed representation of the actuarial, investment and tax aspects of the life insurance business. The author programmed SOFASIM during 1973-74 while he was a consultant to the Society of Actuaries. The present paper is one of four to be presented at a session on SOFASIM at the meeting of the Society of Actuaries, April 1979.

RC 7560 (#32643) 3/8/79
Computer Science 15 pages

SYSTEM PARTITIONING AND ITS MEASURE

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ABSTRACT: Program modules and data structures are interconnected by calls and references in software systems. Partitioning these entities into clusters reduces complexity. For very large systems manual clustering is impractical. A method to perform automatic clustering is described and a metric to quantify the complexity of the resulting partition is developed.

RC 7562 (#32701) 3/15/79
Communications/Computer Science
Mathematics 28 pages

A CLASS OF ROBUST EDGE DETECTORS BASED ON LATIN SQUARES

by

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ABSTRACT: The theory of Latin Square experimental designs is extended to edge detection of multi-grey level pictorial data. Latin Square designs are realized using mask operations either as a square or in linear forms using ANOVA to estimate the model parameters. The test statistics are based upon the robust F-test and the thresholds are selected by an empirical interactive process. A post hoc comparison method is used to confine the edge element ambiguities to two-pixel layer thickness in masks greater than 2×2 pixels. Computer simulations are shown to verify the theory.

*Work performed, in part, when Ivan Kadar was with Grumman Aerospace Corporation, Bethpage, New York 11714.

THE MULTIPLICITY SEMIRING OF A BOOLEAN RING

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Abstract: Given a boolean ring R , a construction of a semiring RB is described whose underlying multiplicative monoid extends the underlying multiplicative monoid of R , whose addition, restricted to pairs of disjoint elements of R , agrees with that of R and which is "smallest" with respect to these properties. The semiring RB may be faithfully represented by a subsemiring of the semiring $(X^{\text{multi}}, +, \cdot)$ of all multisubsets of the set X , for a suitably chosen X . (The $+$ and $\cdot$ of this latter semiring add and multiply multiplicities.) Under the representation of RB in $(X^{\text{multi}}, +, \cdot)$, R goes into a ring of subsets of X , while the image of RB is the smallest subsemiring of $(X^{\text{multi}}, +, \cdot)$ which contains the image of R .

The construction is viewed as an "adjoint situation."

RC 7563 (#32702) 3/15/79
Communications/Computer Science
Mathematics 28 pages

A ROBUSTIZED VECTOR RECURSIVE STABILIZER
ALGORITHM FOR IMAGE RESTORATION

by

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ABSTRACT: The ill-posed problem of object reconstruction (or bandlimited extrapolation) is reformulated in the framework of the general linear model in new recursive parametric forms. The resultant algorithms are shown to be natural stabilizers of the inherent instabilities of both the iterative and non-iterative reconstruction/bandlimited extrapolation methods.

Both robustized and unrobustized versions of the algorithms are given. The recursive algorithms provide immunity to measurement noise outliers in burst noise of high variance. Unlike procedures suggested previously, these methods eliminate the need for stopping rule constraints and ensure convergence of the algorithms. The recursive formulation of the non-iterative method of bandlimited extrapolation is also found to be adaptable to multi-dimensional image restoration.

Computer simulations verify the theory and demonstrate the computational efficiency of the method.

*Work performed, in part, when Ivan Kadar was with Grumman Aerospace Corporation, Bethpage, New York 11714.

RC 7564 (#32724) 3/15/79
Computer Science 7 pages

Three Dimensional Modelling for Automated Mechanical Assembly*

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ABSTRACT

A computer-aided design system for modelling 3-D objects will be described. The system, called the Geometric Design Processor (GDP), converts descriptions of objects in terms of their volume components into a unified polyhedral representation that can be used in many applications. The data structures produced by GDP are used as world models for AUTOPASS, a very high level programming language for mechanical assembly, and as models for producing predicted views of parts in an industrial vision system.

*To be presented at the NSF Workshop on 3-Dimensional Object Representation and Description, Phila., May, 1979.

**Work performed while a visitor at the IBM Thomas J. Watson Research Center.

RC 7570 (#32734) 3/16/79
Communications/Computer Science
Mathematics 37 pages

A CLASS OF THREE-DIMENSIONAL RECURSIVE PARALLELEPIPED MASKS

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ABSTRACT: The theory of the linear hypothesis model, ANOVA, experimental designs and robustized stochastic approximation minimum variance least squares (SAMVLS) are united and applied in a pattern recognition framework to edge element detection and enhancement of large arrays of three-dimensional pictorial data. New three-dimensional recursive parallelepiped masks (TDRPM) suitable for real-time parallel processing and detection of stationary and moving edge elements are developed from multiple pictures taken of a scene in unspecified noise. The TDRPM is implemented by SAMVLS as a $2 \times 2 \times k$ and by ANOVA as a $2 \times 2 \times 5$ mask. The concept of Relative Sensitivity Efficiency (RSE) is introduced to allow comparisons with larger two-dimensional masks. Computer simulations verify the theory and demonstrate the successful performance of TDRPM either as a stationary or a moving edge detector.

*Work performed, in part, when Ivan Kadar was with Grumman Aerospace Corporation, Bethpage, New York 11714.

RC 7580 (#32816) 3/28/79
Computer Science 9 pages

Fast Emulation with Compiled Look-Aside Information

(An Extended Abstract)

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Abstract: We are interested in the problem of running code written in the machine language of one machine on a different machine with a different machine language. In this paper we show how the notions of emulation and translation may be combined together maintaining the completeness of emulation with the speed of translation.

RC 7581 (#32819) 3/28/79
Computer Science 34 pages

SEMANTICS OF PROBABILISTIC PROGRAMS

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ABSTRACT

Two complementary but equivalent semantic interpretations of a high level probabilistic programming language are given. One of these interprets programs as partial measurable functions on a measurable space. The other interprets programs as continuous linear operators on a Banach space of measures. It is shown how the ordered domains of Scott and others are embedded naturally into these spaces. Two general results about probabilistic programs are proved.

RJ 2485 (#32434) 3/13/79
Communications/Computer Science 13 pages

THE ARCHITECTURE OF A DYNAMICALLY-RECONFIGURABLE INSERTION-RING NETWORK

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Abstract: This paper deals with a local network design based on the notions of insertion ring and dynamic reconfiguration. The protocol used for packet transfer is highly bandwidth efficient and has a simple implementation. The physical topology of the network is a general Hamiltonian graph over which a subset of links is used to form a logical ring. Automatic failure recovery is achieved by finding a different logical ring which bypasses the failed components. A microprocessor-based implementation capable of supporting the proposed network is outlined. Together with the control protocol described at the end of this paper, it is possible to connect a wide range of device types to the network using the same hardware.

RJ 2494 (#32744) 3/19/79
Computer Science 20 pages

AN UNDERSTANDING OF MOIRE PATTERNS
IN THE REPRODUCTION OF HALFTONE IMAGES

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ABSTRACT: This paper gives an analysis of the Moire pattern formation in scanning and reproducing halftone pictures. The analysis includes the effects of the aperture size and shape of the reproduction printing process. Also the effects of parallelogram grid sampling as well as square grid sampling have been taken into consideration. A simulation program has been written to synthesize the Moire patterns based upon the Fourier transform of the output picture. Several observations will be discussed and among two of the more important ones are: (a) Moire fringes can result from beating together of clusters of Fourier spatial frequencies and (b) fixed value thresholding intensifies Moiré patterns.

RJ 2495 (#32745) 3/21/79
Computer Science 8 pages

CONTOUR-FORMING, A MECHANISM FOR PROCEDURE AUTOMATION IN THE
OFFICE OF THE FUTURE

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ABSTRACT: This paper presents a mechanism for automating common office procedures. The mechanism is based on a recognition of the fact that the essence of an office procedure is usually embodied in a form and proposes as an essential step the identification of sub-forms of these forms. The sub-forms identify portions of interest to each principal whom a form encounters in its processing. Serendipitously, these same contours, by their relationships to each other, also automatically identify the routing of a filled-in form in an automated version. This discovery is at the heart of the proposal. The paper also presents a conceptual design of an automated system to handle office procedures.

RJ 2500 (#32750) 3/14/79
Computer Science 40 pages

AN EQUIVALENCE BETWEEN RELATIONAL DATABASE DEPENDENCIES AND A SUBCLASS OF PROPOSITIONAL LOGIC

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Fagin [10] demonstrated an equivalence between functional dependencies in a relational database, and a certain subclass of propositional logic. We extend this equivalence to include both functional and multivalued dependencies. Thus, for each dependency there is a corresponding statement in propositional logic. We then show that a dependency (functional or multivalued) is a consequence of a set of dependencies if and only if the corresponding propositional statement is a consequence of the corresponding set of propositional statements. We give examples to show that our techniques are valuable in providing much shorter proofs of theorems about dependencies than have been obtained by more traditional means.

*Work partially supported by NSF grant MCS-76-15255 and by a grant from Bell Laboratories

RC 7586 (#32828) 3/29/79
Computing Systems 22 pages

ON-LINE MONITORING AND CONTROL OF VM/370 USAGE

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ABSTRACT: An overview is given of RESLIM (Resource Limiter), a facility on the IBM T. J. Watson Research Center's VM/370 systems that is designed to help reduce waste of scarce/expensive computer resources (e.g., CPU time) resulting from program loops, excessive resource consumption, and user actions that are contrary to the computing center's resource allocation policies for maintaining adequate response time. RESLIM consists of two components. The RESLIM virtual machine periodically monitors selected VM/370 users' consumption of certain computer resources and takes actions designed to make better use of these resources whenever a monitored user's consumption of such a resource exceeds a specified level. The RESLIM command enables users and authorized computing center personnel to inform the RESLIM virtual machine about the usage to be monitored and the actions to be taken when this usage exceeds a level specified by the user or the computing center.

RC 7551 (#32646) 3/9/79
Mathematics 37 pages

FAST COMPUTATION OF PADÉ APPROXIMANTS AND TOEPLITZ SYSTEMS OF EQUATIONS VIA THE EXTENDED EUCLIDEAN ALGORITHM

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Typed by: Nancy Perry

ABSTRACT: We present a new fast algorithm to solve an n by n Toeplitz system of equations, $Tz = b$. Our algorithm is based on using the Fast Extended Euclidean Algorithm and it has a complexity of $O(n \log^2 n)$. The established algorithm for solving Toeplitz systems is Trench's algorithm which has a complexity $O(n^2)$. Furthermore, our algorithm has no restrictions, i.e., there are no degenerate cases. In contrast, the Trench algorithm requires that all principle minors of T have nonzero determinants. Recently R. Brent announced a fast $O(n \log^2 n)$ algorithm to solve Toeplitz systems via continued fraction expansion. His algorithm suffered from a degeneracy problem that was much akin to the degeneracy in Trench's algorithm.

We show that Toeplitz computations can be obtained as byproducts of the Padé Table Computation. Also we prove that the entries of the Padé Table can be computed by the Extended Euclidean Algorithm. Our computational results in this regard are stronger. We have improved and extended the HGCD algorithm of Aho, Hopcroft, and Ullman and the fast GCD algorithm of R. Moenck in two significant ways. First we have developed an improved HGCD algorithm called EMGCD (for Extended Middle GCD). The cost of EMGCD is less than the cost of HGCD; however, both algorithms have an $O(n \log^2 n)$ cost. The second improvement comes from generalizing EMGCD. We have produced algorithm PRSDC (Polynomial Remainder Sequence Divide and Conquer) which produces any iterate in the PRS sequence and not just the middle term. The cost of algorithm PRSDC is also $O(n \log^2 n)$.

Algorithm PRSDC has many useful applications. Our main application results in a fast computational algorithm for entries of the Padé Table. Let $m+n = 2N$ and set $U_0 = x^{2N+1}$ and $U_1 = a_0 + a_1x + \dots + a_{2N}x^{2N}$. By applying algorithm PRSDC to U_0 and U_1 we can compute in $O(N \log^2 N)$ any Padé Table entry (m,n) along the anti-diagonal $m+n = 2N$.

A Toeplitz matrix

$$T = \begin{pmatrix} a_n & & & a_0 \\ & \ddots & & \\ & & \ddots & \\ a_{2n} & & & a_n \end{pmatrix}$$

is associated with the polynomial U_1 . We show that the (n,n) Padé approximant contains the solution to the system $Tx = e_0$. Similarly the (n,n) Padé approximant associated with T^T solves $T^T y = e_0$. We also prove that $\det T \neq 0$ if and only if the numerator polynomial of the (n,n) Padé approximant has full degree n .

We show that a formula, due to Trench, can be used to compute $Tz = b$ from x and y in $O(n \log n)$ where x and y are the first column and row of T^{-1} . We discuss the degenerate case $x_0 = T_{11}^{-1} = 0$ of Trench's formula and show when degeneracy occurs that a companion formula, the discrete analog of the Christoffel-Darboux formula, is always valid. It also can be used to compute $Tz = b$ from an x and y of the Padé computation in $O(n \log n)$. The basis of our fast Toeplitz solver is the fast computation of at most four Padé approximants combined with the fast computation of a Trench-like formula.

We also present new complexity results for banded Toeplitz systems. Let T_{bc} be a banded Toeplitz matrix whose semi-bandwidths are b and c . By applying algorithm PRSDC we can solve $T_{bc} z = d$ in $O(n \log n) + O((b+c) \log^2(b+c))$. The best previous result of $O(n \log n) + O((b+c)^2)$ is due to Jain. A few remarks are included on Berlekamp's algorithm. We define the key equation of BCH Decoding and show how the extended Euclid algorithm can be used to solve it. The underlying key equation that the Berlekamp algorithm solves is a Toeplitz system; the complexity of his algorithm is $O(n^2)$. We show that the solution to the key equation can be found by applying algorithm EMGCD; hence the complexity of solving the key equation is lowered to $O(n \log^2 n)$.

RC 7557 (#32673) 3/13/79
Computer Science 28 pages

Proving the Correctness of Regular Deterministic Programs: A Unifying Survey Using Dynamic Logic.

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Typed by Shirley Coleman

ABSTRACT

The simple set WL of deterministic *while* programs is defined and a number of known methods for proving the correctness of these programs are surveyed. Emphasis is placed on the tradeoff existing between data-directed and syntax-directed methods, and on providing, especially for the latter, a uniform description enabling comparison and assessment. Among the works considered are the Floyd/Hoare invariant assertion method for partial correctness, Floyd's well-founded sets' method for termination, Dijkstra's notion of weakest precondition, the Burstall/Manna and Waldinger intermittent assertion method and more. Also, a brief comparison is carried out between three logics of programs: dynamic logic, algorithmic logic and programming logic.

[†]Part of this work was done while the author was with the Laboratory for Computer Science at the Massachusetts Institute of Technology, and was supported by NSF grants MCS76-18461 and MCS77-19754.

RC 7559 (#32668) 3/13/79
Mathematics 19 pages

ON EMBEDDING GRAPHS IN GRIDS

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Abstract. This note is a free translation of Sections 1 and 2 of M. A. Sheidvasser's "O dline i shirine razmeshchenii grafov v reshetkakh" which appeared in *Problemy Kibernetiki* 29 (1974) 63-102. The major thrust of these sections of Sheidvasser's paper is to develop techniques for bounding, both above and below, the average dilation of the edges of graphs which are embedded in grids (or, "array graphs"); the remainder of his paper is devoted to applying the techniques developed to a variety of families of graphs. The "freeness" in our translation includes the generalization of Sheidvasser's results to source graphs with edges weighted by real numbers.

RC 7565 (#32726) 3/15/79
Mathematics 18 pages

CONNECTED AND ALTERNATING VECTORS
POLYHEDRA AND ALGORITHMS

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ABSTRACT: Given an undirected connected graph $G = (V, E)$ and $\{G_i = (V_i, E_i) : i \in I\}$ all connected nontrivial subgraphs of G , the connected vectors $a^i \in \mathbb{R}^E$ of G are the incidence vectors of E_i , $i \in I$.

The extreme points of $B = \{x \in \mathbb{R}^E : a^i x \leq |V_i| - |E_i|, i \in I\}$ are shown to be integer $(0, \pm 1)$ and characterized. They are the alternating vectors b^k , $k \in K$, of G .

G being a tree, the extreme points of $A = \{x \in \mathbb{R}^E : x \geq 0, b^k x \leq 1, k \in K\}$ are shown to be the connected vectors of G together with the origin. For the four LP's associated with B and A , good algorithms are given and total dual integrality of B and A proven.

RC 7566 (#32730) 3/16/79
Computer Science 33 pages

ON LIFTED PROBLEMS†

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Typed by: Martha J. Pierce

Abstract: This study may be viewed from the more general context of a *theory of computational problems*. An *environment* $E = \langle L, D \rangle$ consists of a class of structures D and a language L for D . A *problem* in E is a pair of sets of formulas $P = \langle \Pi | \Gamma \rangle$, with *problem predicate* Π . Let $E_{\text{real}} = \langle L_{\text{real}}, \{\mathbb{R}\} \rangle$ and $E_{\text{lin}} = \langle L_{\text{lin}}, D_{\text{lin}} \rangle$ where $\mathbb{R}$ are the reals, D_{lin} is the class of totally ordered structures, L_{real} and L_{lin} are the languages of real ordered fields and linear orders, respectively. A problem $P = \langle \Pi | \Gamma \rangle$ in E_{real} is a *lifted problem* (from E_{lin}) if $\Pi \in L_{\text{lin}}$. The following interprets an informal conjecture of Yao:

CONJECTURE: Binary comparisons can solve non-redundant, full lifted problems in E_{real} as efficiently as general linear comparisons.

The conjecture remains open. We may attack the conjecture by eliminating those comparisons that *do not help* or by studying those subclass of problems that are *not helped* by general linear comparisons. Various partial results are obtained, corresponding to these two approaches.

† This paper was presented at the 19th Annual IEEE Foundation of Computer Science Conference, October 16-18, 1978, Ann Arbor, Michigan. Some minor changes had been made and the proof of Theorem 3 is rectified.

* Part of this research was done while the author was a summer employee at IBM Thomas J. Watson Research Center, Yorktown Heights, New York, 1978. This work was also supported in part by NSF Grant #MCS 78-81486 and by U.S. Army Contract #DAAAG 29-75-C-0024.

RC 7574 (#32794) 3/23/79
Computer Science 41 pages

RATIONALIZING MANY-SORTED ALGEBRAIC THEORIES

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Typed by Marilyn McCrae and Martha Cooper on CMS (sk.2141)

ABSTRACT

An informal exposition of the work of the ADJ group on algebraic semantics is given. The intent is to introduce the concepts and terminology in an intuitive way with examples drawn from computer science. The reader is referred to ADJ's own technical papers for a precise account and many additional examples.

[†] This work was carried out while the author was visiting the Mathematical Sciences Department of the Thomas J. Watson Research Center in the summer of 1977.

RC 7554 (#32656) 3/12/79
Mathematics 34 pages

DUALITY AND PRICING IN MULTIPLE RIGHT-HAND SIDE LINEAR PROGRAMMING PROBLEMS

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ABSTRACT: The main problem considered is a linear program except that the right-hand side, instead of being fixed, can be any one of a finite set. We begin with linear programming and a discussion of pricing functions in the degenerate case. It is shown that pricing functions for linear programs (which are positively homogeneous and subadditive) suffice as dual functions for the multiple right-hand side problems, but pricing functions for the latter problem need not be convex. Finally, a symmetric form of duality is introduced.

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RC 7588 (#32847) 4/2/79
Computer Science 26 pages

**MORE ON ADVICE ON STRUCTURING COMPILERS
AND PROVING THEM CORRECT**

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ABSTRACT

Following F. Lockwood Morris ("Advice on structuring compilers and proving them correct," 1973), we show how serious algebraic ideas can be employed in giving the semantics of non-trivial source and target languages, in specifying a compiler, and in proving it correct.

RC 7595 (#32868) 4/9/79
Computer Science 15 pages

MANY-SORTED AND ORDERED ALGEBRAIC THEORIES

Eric G. Wagner, Jesse B. Wright, James W. Thatcher

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ABSTRACT

We present background definitions and results concerning many-sorted algebraic theories and ordered many-sorted algebraic theories used in our work in order-algebraic semantics. This material is the basis for further work on completions of ordered theories.

RC 7596 (32874) 4/11/79
Computer Science

The Role of Context in Creating Names•

John M. Carroll
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Yorktown Heights, New York 10598

Abstract: A study of how people name novel referents was presented. Subjects created names for individuals characterized by role descriptions. The role descriptions were either embedded in context scenarios or not. The Context Embedded condition elicited names that were less directly and literally based on the actual content of the role descriptions than did the Context Free condition. Context scenarios that *involved* the individual denoted by the role description elicited names less literally based on the actual role description than did less involving scenarios. Less literal names appeared to directly 'incorporate' context material. The importance and potential influences of contextual variables on naming were discussed.

RC 7592 (#32857) 4/4/79
Computer Science 18 pages

Stationary State Probabilities at Arrival Instants for Closed Queueing Networks with Multiple Types of Customers

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ABSTRACT: We consider closed networks of interconnected service centers with multiple types of customers and multiple classes, whose stationary state probabilities at arbitrary times have a product form. A customer can change its class but not its type as it traverses the network. We show that the stationary state probabilities at instants at which customers of a particular type arrive at a particular service center and enter a particular class are equal to the stationary state probabilities at arbitrary times for the network with one less customer of that type. Applications of this result are given.

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No. 001 - A SURVEY OF PROGRAM PROOF TECHNOLOGY
by Jacob T. Schwartz, Sept. 1978

This paper surveys the main approaches that have been taken to the problem of proving programs correct, and attempts to assess prospects for this field and to identify areas which deserve stress. Proof-verification techniques are seen as an essential element in program verification, and the present status of proof verification technology is reviewed.

No. 002 - TWO APPROACHES TO INTERPROCEDURAL DATA FLOW ANALYSIS
by Micha Sharir and Amin Pnueli, Sept. 1978

Two approaches to interprocedural data-flow analysis are presented. Both approaches extend the classical theory of data-flow analysis to handle interprocedural flow correctly. Several algorithms are sketched and a comprehensive study establishing basic properties of their output is given.

No. 003 - SECURITY IN OPERATING SYSTEMS: SEPARATING THE ROLES OF RIGHTS
by Elaine J. Weyuker, Oct. 1978

Several possible models of protection mechanisms for operating systems are discussed. These models represent modifications of models introduced by Harrison, Ruzzo, and Ullman, and Jones, Lipton and Snyder. The modifications represent attempts to rectify certain unrealistic features. The effects of the modifications on the decidability of key questions is investigated, as well as complexity questions when appropriate. It is demonstrated that for each modification considered, decidability and complexity results are never worse than the less reasonable, original models.

No. 004 - PROBABILISTIC ALGORITHMS FOR VERIFICATION OF POLYNOMIAL IDENTITIES
by Jacob T. Schwartz, Oct. 1978

The startling success of the Rabin-Strassen-Solovay primality algorithm, together with the intriguing foundational possibility that axioms of randomness may constitute a useful fundamental source of mathematical truth independent of the standard axiomatic structure of mathematics, suggests a vigorous search for probabilistic algorithms. In illustration of this observation, we present various fast probabilistic algorithms, with probability of correctness guaranteed a priori, for testing polynomial identities and properties of systems of polynomials. Ancillary fast algorithms for calculating resultants and Sturm sequences are given. Probabilistic calculation in real arithmetic, previously considered by Davis, is justified rigorously, but only in a special case. Theorems of elementary geometry can be proved much more efficiently by the techniques presented than by any known artificial intelligence approach.

No. 005 - A NOTE AND A DIALOG ON ASPECTS OF THE DOD COMMON LANGUAGE (IRONMAN)
by Robert B.K. Dewar, Oct. 1978

This report contains a note written following a discussion of the real precision problem in Ironman at the Twente Meeting of WG2.4 earlier this year. It also contains a verbatim, unexpurgated version of a written dialog on exception handling in green which occurred at this conference during one of the sessions.

No. 006 - TRANSLATABILITY AND DECIDABILITY QUESTIONS FOR RESTRICTED CLASSES
OF PROGRAM SCHEMAS, by Elaine J. Weyuker, Oct. 1978

Two new classes of schemas are introduced: the reachable schemas and the semifree schemas. A schema is reachable if every statement in the schema is executed under some interpretation. A schema is semifree if every test in the schema is necessary in the sense that each exit of the test is taken under some interpretation. It is shown that most of the standard decision problems are unsolvable for schemas in these two classes, and that there can be no algorithm which effectively translates an arbitrary schema into an equivalent reachable or semifree schema, even though such equivalent schema always exist. These classes are also compared to the free and liberal schemas, and interclass translatability questions are investigated. It is demonstrated that every reachable schema can be effectively translated into a semifree schema, even though it is not decidable whether a reachable schema is semifree.

No. 007 - AUTOMATIC DISCOVERY OF HEURISTICS FOR NON-DETERMINISTIC PROGRAMS
by Salvatore J. Stolfo and Malcolm C. Harrison, Jan. 1979

This paper discusses one way to limit the cost of executing Declarative-based non-deterministic programs. The approach we take is to develop control heuristics for a family of problems from traces of sample solutions generated during a training session with a human expert. Algorithms are presented which recognize a predefined set of patterns in the sequence of "knowledge applications" and which compile descriptions of these patterns in a control language called CRAPS. The CRAPS descriptions generated are then used for guidance in solving subsequent problems. We discuss the utility of such an approach and give an example of a generated CRAPS description.

No. 008 - THEORIES OF PROGRAM TESTING AND THE APPLICATION OF REVEALING
SUBDOMAINS, by Elaine J. Weyuker and Thomas J. Ostrand, Feb. 1979

A theory of test data selection proposed by Goodenough and Gerhart is examined and a number of theoretical and pragmatic deficiencies are identified. The concepts of a revealing test criterion and a revealing subdomain are proposed to overcome some of these weaknesses, and to provide a realistic basis for a theory of testing. A methodology for forming revealing subdomain partitions is described, and illustrated with three examples to which other testing methodologies have been applied in the literature.

No. 009 - MICRO-BALM - A PROGRAMMING LANGUAGE FOR MICROCOMPUTERS
by Malcolm C. Harrison, Jan. 1979

This report describes nBALM, a new programming language which has been developed for microcomputers. It provides incremental program construction and debugging, flexible data-types, powerful control structures including recursive and interrupt-driven procedures, and can run in a 16K byte microprocessor without secondary storage.

No. 010 - COMPILE-TIME ANALYSIS OF DATA LIST-FORMAT LIST CORRESPONDENCES
by Paul Abrahams and Lori Clarke, Feb. 1979

Formatted input-output is available in a number of programming languages. In the most general case, the correspondence between data items and format items cannot be determined during compilation, and so it is determined dynamically during execution. However, in most pairs of data and format lists that occur in practice, determination of the correspondence is in fact possible during compilation. Although some commercial compilers make this determination, there is little published literature on the subject. In this paper, we briefly examine three areas in which compile-time determination of the data-format correspondence is useful: optimization, program validation, and automatic test data generation. A formalism for stating the problem is given, and a solution is discussed in terms of formal language theory. Using this formalism, an algorithm for determining the correspondence is given, and its application is illustrated by examples in both PL/I and FORTRAN.

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M.C. DEPARTMENT OF COMPUTER SCIENCE REPORTS

IW 79/77

SAVITCH W.J., VITANYI P.M.B.

Linear time simulation of Turing machines with head-to-head jumps.

Amsterdam, Mathematisch Centrum, Apr. 1977. (12 p)
AMS(MOS) Classification (1970): 94A30, 68A20, 68A25, 68A55.
ACM-CR Categories: 5.26, 5.25.

The main part of this paper shows that, given a Turing machine with several read-write heads per tape, and which has the additional one move shift operation "shift a given head to the position of some other given head", one can effectively construct a multitape Turing machine with a single read-write head per tape which simulates it in linear time i.e. if the original machine operates in time $T(n)$, then the simulating machine will operate in time $cT(n)$, for some constant c .

KEY WORDS AND PHRASES: multihead Turing machines, head-to-head jumps, linear time simulation.

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M.C. DEPARTMENT OF COMPUTER SCIENCE REPORTS

IW 69/76

SAVITCH W.J., STIMSON M.J.

Time bounded random access machines with parallel processing.
(Prepublication)

Amsterdam, Mathematisch Centrum, Nov. 1976. (34 p)
AMS(MOS) Classification (1970): 68A20.
ACM-CR Category: 5.25, 5.26, 5.23.

The RAM model of COOK and RECKHOW (J. Comput. System Sci. 7 (1973), 354-375) is extended to allow parallel recursive calls and the elementary theory of such machines is developed. The uniform cost criteria is used. The results include proofs of (1) the equivalence of nondeterministic and deterministic polynomial time for such parallel machines and (2) the equivalence of polynomial time on such parallel machines and polynomial space on ordinary nonparallel RAMs.

KEY WORDS AND PHRASES: parallelism, nondeterminism, random access machine, time, storage.

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M.C. DEPARTMENT OF COMPUTER SCIENCE REPORTS

IW 96/78

KLINT P., SINT M.

A framework for the integration of graphics and pattern recognition.
(Prepublication)

Amsterdam, Mathematisch Centrum, May 1978. (22 p)
AMS(MOS) Classification (1970): 68A45.
ACM-CR Categories: 3.63, 8.2.

A model is presented that describes a symmetric input/output function in a computer graphics system. This model is based on the construction of a symmetric input function by means of pattern recognition. Both theoretical and implementational aspects of this model are discussed.

KEY WORDS AND PHRASES: computer graphics, pattern recognition, symmetric input/output.

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M.C. DEPARTMENT OF COMPUTER SCIENCE REPORTS

IW 97/78

APT K.R.

A sound and complete Hoare-like system for a fragment of PASCAL.
(Prepublication)

Amsterdam, Mathematisch Centrum, July 1978. (59 p)
AMS(MOS) Classification (1970): 68A05.
ACM-CR Category: 5.24.

A fragment of PASCAL is considered in which local declarations of simple variables, of array variables and of systems of mutually recursive parameterless procedures are allowed. A Hoare-like proof system for the fragment is presented which is proved to be both sound and complete in the sense of Cook.

KEY WORDS AND PHRASES: local declarations, substitution, denotational semantics, partial correctness, Hoare-like proof system, soundness, completeness in the sense of Cook.

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M.C. DEPARTMENT OF COMPUTER SCIENCE REPORTS

IW 70/76

VITANYI P.M.B.

Achievable high scores of ϵ -moves and running times in DPDA computations.
(Prepublication)

Amsterdam, Mathematisch Centrum, Dec. 1976. (8 p)
AMS(MOS) Classification (1970): 68A25, 68A20, 94A30.
ACM-CR Categories: 5.23, 5.25, 5.26, 4.1.

Large scores in the number of consecutive ϵ -moves a DPDA can make without entering a loop or decreasing its stack below the original stack height are investigated. The achieved scores are very near to an upper bound in the general case and are the upper bound for one-state DPDA's. Upper and lower bounds are derived for the worst case running times of accepting DPDA computations.

KEY WORDS AND PHRASES: deterministic pushdown automata computations, maximal number of ϵ -moves, largest running times, highest inefficiency.

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M.C. DEPARTMENT OF COMPUTER SCIENCE REPORTS

IW 71/76

APT K.R.

Equivalence of operational and denotational semantics for a fragment of PASCAL.
(Prepublication)

Amsterdam, Mathematisch Centrum, Dec. 1976. (27 p)
AMS(MOS) Classification (1970): 68A05.
ACM-CR Category: 5.24.

A fragment of PASCAL is considered in which nested systems of procedure declarations are allowed. Procedures can call parameters by value or by variable. Three semantics for the fragment are considered, two denotational and one operational, and all three are proved to be equivalent.

KEY WORDS AND PHRASES: denotational semantics, operational semantics, call-by-value, call-by-variable, recursive procedures, nested systems of procedure declarations.

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M.C. DEPARTMENT OF COMPUTER SCIENCE REPORTS

IW 72/76

VITANYI P.M.B., SAVITCH W.J.

On inverse deterministic pushdown transductions.
(Prepublication)

Amsterdam, Mathematisch Centrum, Dec. 1976. (31 p)
AMS(MOS) Classification (1970): 68A20, 68A25, 68A30, 94A30.
ACM-CR Categories: 5.23, 5.25, 5.26, 5.27.

Classes of source languages which can be mapped by a deterministic pushdown (DPDA-) transduction into a given object language (while their complement is mapped into the complement of the object language) are studied. Such classes of source languages are inverse DPDA transductions of the given object language; similarly for classes of object languages.

The inverse DPDA transductions of the Dyck sets are studied in greater detail: they can be recognized by a DLBA operating in time $O(n^2)$ but do not comprise all context free languages; their emptiness problem is unsolvable and their closure under homomorphism constitutes the r.e. sets. For each object language L we can exhibit a storage hardest language for the class of inverse DPDA transductions of L ; similarly for the class of regular and context free object languages.

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M.C. DEPARTMENT OF COMPUTER SCIENCE REPORTS

IW 82/77

BAKKER J.W. de

Semantics of infinite processes using generalized trees.

Amsterdam, Mathematisch Centrum, May 1977. (7 p)
AMS(MOS) Classification (1970): 68A05.
ACM-CR Category: 5.24.

A proposal is outlined for the definition of the meaning of infinite processes within the framework of denotational semantics. An infinite process obtains as its meaning a function from (generalized) trees to trees.

A combination of least-fixed-point and greatest-fixed-point techniques is used to characterize both trees and processes.

KEY WORDS AND PHRASES: denotational semantics, infinite processes, trees, least fixed point, greatest fixed points.

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M.C. DEPARTMENT OF COMPUTER SCIENCE REPORTS

IW 87/77

VITANYI P.M.B.

Physical time growth functions associated with developmental models operating in physiological time.
(Prepublication)

Amsterdam, Mathematisch Centrum, Oct. 1977. (21 p)
AMS(MOS) Classification (1970): 68A30, 68A25, 94A30, 92A05.
ACM-CR Categories: 5.22, 5.23.

The theory of growth functions as developed on the basis of Lindenmayer systems (also called developmental models) seems unable to account for several phenomena occurring in developmental biology. If, however, we drop the assumption that changes (=rewriting of strings) in the system occur at unit time intervals, we can describe phenomena like progressive dissipation of growth energy, biological rhythms, changes in environmental conditions which influence the growth rate etc., in the model. Thus we derive a hybrid model by assuming discrete cells and instantaneous cell division but continuous time. The number of past rewritings then corresponds to physiological time and the total time consumed to physical time.

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M.C. DEPARTMENT OF COMPUTER SCIENCE REPORTS

IW 83/77

BAKKER J.W. de

Recursive programs as predicate transformers.

Amsterdam, Mathematisch Centrum, June 1977. (15 p)
AMS(MOS) Classification (1970): 68A05.
ACM-CR Category: 5.24.

The connections between two ways of assigning meanings to programs are investigated. On the one hand we have the approach in which a program determines a function from states to states, on the other hand the proof-theory-oriented approach, advocated in particular by Dijkstra, where a program is viewed as a mapping from postconditions to weakest preconditions. The main result is a theorem which settles the mathematical relationship between the two approaches for a language including nondeterminacy and full recursion. We used the methodology of denotational semantics, extended with the Egli-Milner ordering to deal with nondeterminacy. The paper concludes with some remarks on the possibility of a syntactic characterization of weakest preconditions, and on a recent theorem by Basu and Yeh on weakest preconditions for the while statement.

KEY WORDS AND PHRASES: predicate transformers, recursion, denotational semantics, weakest preconditions, Egli-Milner ordering, while statement.

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M.C. DEPARTMENT OF COMPUTER SCIENCE REPORTS

IW 81/77

VITANYI P.M.B.

How "good" can a graph be n -colored?

Amsterdam, Mathematisch Centrum, June 1977. (12 p)
AMS(MOS) Classification (1970): 05C15, 68A20.
ACM-CR Categories: 5.32, 5.25.

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The problem of how "near" we can come to an n -coloring of a given graph is investigated. That is: what is the minimum possible number of edges joining equicolored vertices if we color the vertices of a given graph with n colors? In its generality the problem of finding such an optimal color assignment to the vertices (given the graph and the number of colors) is NP-complete. For each graph G , however, colors can be assigned to the vertices in such a way that the number of offending edges is less than or equal to the total number of edges divided by the number of colors. Furthermore, an $O(epn)$ deterministic algorithm for finding such an n -color assignment is exhibited where e is the number of edges and p is the number of vertices of the graph ($e \geq p \geq n$). A priori solutions for the minimal number of offending edges are given for complete graphs; similarly for equicolored K_m in K_p and equicolored graphs in K_p .

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IW 79/77

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AMS(MOS) Classification (1970): 94A30, 68A20, 68A25, 68A55.
ACM-CR Categories: 5.26, 5.25.

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The main part of this paper shows that, given a Turing machine with several read-write heads per tape, and which has the additional one move shift operation "shift a given head to the position of some other given head", one can effectively construct a multitape Turing machine with a single read-write head per tape which simulates it in linear time i.e. if the original machine operates in time $T(n)$, then the simulating machine will operate in time $cT(n)$, for some constant c .

KEY WORDS AND PHRASES: multihed Turing machines, head-to-head jumps, linear time simulation.

M.C. DEPARTMENT OF COMPUTER SCIENCE REPORTS

IW 84/77

APT K.R., MEERTENS L.G.L.T.

Completeness with finite systems of intermediate assertions for recursive program schemes.
(Prepublication)

Amsterdam, Mathematisch Centrum, Sep. 1977. (15 p)
AMS(MOS) Classification (1970): 68A05.
ACM-CR Category: 5.24.

It is proved that in the general case of arbitrary context-free schemes a program is (partially) correct with respect to given initial and final assertions if and only if a suitable finite system of intermediate assertions can be found. Assertions are allowed from an extended state space. This result contrasts with the results of DE BAKKER and MEERTENS (J. Comput. System Sci. 11(1975)3, pp. 323-357), where it is proved that if assertions are taken from the original state space V , then in the general case an infinite system of intermediate assertions is needed. In the case of functional schemes (where any deterministic scheme is a functional one) one can take $V \times V$ for the extended state space, thus obtaining a semantical counterpart of the use of auxiliary variables.

KEY WORDS AND PHRASES: partial correctness, intermediate assertions, relational framework, extended state space, recursive program schemes.

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- ☐ **N° 333** **Proof and synthesis of semantic attributes in compiler definition**
 P. Deransart

La définition d'un compilateur par attributs sémantiques présente un inconvénient qui limite son utilisation : elle comporte un grand nombre de définitions souvent triviales ainsi que des redondances qui alourdissent la description et augmentent le risque d'erreurs d'écriture.

La description d'un compilateur par les seules définitions d'attributs guides et la synthèse des autres définitions à partir de spécifications est présentée dans ce rapport comme un essai pour réduire ces inconvénients. La synthèse est dérivée de la méthode de preuve introduite par Amirchahy, Néel et Pair.

One of the drawbacks of compiler definition by semantic attributes is the great number of attribute definitions and the redundancies that occur in such definitions. Automatic synthesis of attribute definitions from some specification plus deriving attribute definition is presented as an attempt to make such a method more practical. The synthesis is derived from the proof method as described by Amirchahy, Néel and Pair.

- ☐ **N° 334** **Semantics of procedures as an algebraic abstract data type**
 M.-C. Gaudel, Ph. Deschamp, M. Mazaud

Nous proposons d'utiliser les types abstraits algébriques pour formuler la sémantique des langages de programmation. Nous présentons l'exemple réaliste d'un langage comportant des procédures récursives et des variables globales. On obtient un modèle simple de la sémantique d'un tel langage. L'intérêt de cette approche est qu'elle permet de spécifier et de prouver des compilateurs.

Algebraic abstract data types can be used as a framework to formalize the semantics of programming languages.

We give here an example of a language with recursive procedures and global variables. This approach allows to specify and prove compilers.

- ☐ **N° 335** **Performance evaluation of a cache memory for a mini-computer**
 M. Badel, J. Leroudier (Laboria)

Nous étudions, dans cet article, les performances d'une anté-mémoire pour un mini-ordinateur qui, dans notre cas, est un MITRA 125 de la SEMS (France). Les performances sont évaluées, en termes de taux de succès et d'accélération de la machine visée, grâce à un simulateur alimenté par des traces d'adresses prélevées durant l'exécution de programmes réels. Comme de telles performances dépendent fortement du comportement des programmes analysés, ce comportement et son influence sur les performances sont soigneusement étudiés.

In this paper, we study the performance of a cache memory for a mini-computer, namely a MITRA 125 manufactured by SEMS, France. The performance is evaluated, in terms of hit ratios and speeding-ups of the target machine, via a simulator fed with address traces picked up during execution of real programs. Since such a performance strongly depends upon the behaviour of the programs analyzed, the impact of program behaviour on performance is carefully studied.

□ N° 336 Domaines concrets

G. Kahn (Iria-Laboria), G. Plotkin (Univ. of Edinburgh)

Dans ce rapport, on développe la théorie d'une variété particulière de domaines de calculs appelés **domaines concrets**. L'objet de cette théorie est de trouver un cadre convenable pour les notions de calcul en coroutine et d'évaluation séquentielle.

*This reports introduces the theory of a particular kind of computation domains called **concrete domains**. The purpose of this theory is to find a satisfactory framework for the notions of coroutin computation and sequentiality of evaluation.*

□ N° 337 Problems of clustering and recent advances

E. Diday

La classification automatique a été souvent présentée comme un ensemble de techniques dont le principal mérite est de donner des classes d'objets. Pour adopter un point de vue différent, on est amené à se poser les deux questions suivantes :

- 1) quels sont les principaux choix de base que l'utilisateur doit faire avant toute classification ?
- 2) est-il possible de montrer que la plupart des problèmes classiques de classification peuvent s'exprimer sous forme d'un critère à optimiser ?

On aborde ensuite le problème des tableaux de grande taille. On montre que dans ce cas, beaucoup de problèmes de la statistique classique (estimation de densité, régression, discrimination, analyse factorielle, analyse canonique, etc ...) peuvent être enrichis en considérant le point de vue local apporté par la classification automatique.

The clustering problem consists in finding and ordering groups of objects, using the relations defined by the variables which characterize these objects. Traditionally, this field has been presented as a set of techniques which were developed for the sole purpose of finding clusters. We adopt here a different point of view.

We shall briefly go over the three following points : 1) What are the basic choices that the user who wishes to classify multidimensional data will have to make at the beginning ?

1) We then show that most problems arising in applications can be formulated in terms of the optimization of a mathematically definable criterion.

2) Last, we show that in many statistics problems (probabilistic or not) we can obtain an additional understanding if we take the clustering point of view, which emphasizes local properties which turn out to be important in practical problems.

□ N° 338 Pattern recognition by a piecewise polynomial approximation with variable joints

Ch. Charles, Y. Lechevallier (Iria-Laboria)

Lorsque nous désirons mémoriser de façon condensée l'information fournie par une fonction $g(x)$ échantillonnée en différents points d'un intervalle $[a,b]$, nous cherchons une fonction dépendant d'un petit nombre de paramètres qui approxime au mieux $g(x)$, au sens des normes L_2 et L_∞ . En pratique les fonctions les plus utilisées sont les polynômes ; toutefois, ceux-ci ne peuvent avoir de pentes infinies suivies de pentes nulles sur de courts intervalles si leurs degrés sont faibles, ce qui est nécessaire pour éviter les instabilités numériques. Nous avons donc choisi une approximation par des fonctions polynomiales par morceaux. Ces fonctions sont définies par division de l'intervalle $[a,b]$ en sous-intervalles dont les limites sont variables. Bien que la fonction approximante soit non linéaire et qu'on ne possède de solution générale, ce problème est de grande importance puisque la clé du succès d'une approximation locale réside dans l'emplacement de ces points limites.

Les algorithmes que nous présentons emploient de façon simultanée la classification automatique (algorithme de transfert, algorithme de Fisher) et les techniques de régression (norme L_2) ou de résolution d'un système linéaire surdimensionné au sens de Chebyshev (norme L_∞).

Ces algorithmes présentent l'avantage de pouvoir être aisément généralisés aux cas de contours et permettent d'introduire des contraintes de continuité, de dérivabilité (fonctions splines) aux points limites, donnant ainsi ces propriétés à la fonction approximante globale sur $[a,b]$.

The algorithms we propose for recognizing and memorizing curves employ simultaneously regression techniques and non hierarchical clustering.

We simultaneously search for a K-contiguous partition of the set of data and for K-regression

hyperplanes that optimize a criterion measuring the proximity between the classes and the hyperplanes. In order to store a curve, we use the points separating two of the classes as well as the polynomial functions.

We also propose regression algorithms under local constraints enabling the stored curve to be continuous, with continuous derivatives or spline.

- **N° 339** **Hadamard's variational formula a mixed problem and an application to a problem related to a Signorini-like variational inequality**
 Bernadette Palmerio (Univ. Nice), A. Dervieux (Iria/Laboria)
 Nous donnons une formule de variation par rapport au domaine géométrique (formule de Hadamard) de la solution d'un problème mêlé ; nous mettons en évidence les singularités qu'elle contient et nous en tirons une méthode d'approche du problème du contrôle optimal d'un problème en relation avec une inéquation variationnelle elliptique du type Signorini.
We give a variational formula for the solution of a Mixed Boundary Value Problem when the geometrical domain is perturbed (Hadamard's Variational Formula) ; we show that this formula contains singularities ; the result is used to construct a new approach to the optimal control problem for a problem related to a Signorini-like Elliptic Variational Inequality.
- **N° 340** **A study of flows in queueing networks and an approximate method for solution**
 G. Pujolle, Ch. Soula (Iria/Laboria)
 Nous introduisons une nouvelle méthode approchée pour étudier un réseau de files d'attente à un ou plusieurs serveurs. Cette méthode est basée sur une étude théorique de la nature des flots dans un réseau de Jackson.
A new approximate approach to study open single or many servers queueing network is introduced here. The method is based on a theoretical study of the nature of flows to be Poisson or not, in a Jackson network.
- **N° 341** **Distribution of the flows in a general Jackson network**
 J. Labetoulle, G. Pujolle, Ch. Soula (Iria/Laboria)
 Des systèmes de files d'attente du type «Jackson» sont considérés dans cet article. Les distributions des intervalles de temps entre deux entrées et entre deux sorties sont calculées pour une file M/M/1 avec rebouclage, un système de deux files d'attente en série avec rebouclage et un réseau de deux stations entièrement interconnecté. Finalement nous montrons l'égalité des deux précédentes distributions pour chaque file d'un réseau de Jackson général. Nous analysons également la distribution des intervalles de temps entre deux rebouclages dans deux modèles particuliers.
Several queueing systems with feedback are analyzed in this paper. We obtain the distribution of the interinput times and interoutput times for a M/M/1 queue with feedback, a two tandem queues system with feedback and a particular open network with two stations interconnected. And finally we show the equality of the distributions of the interinput times and interoutput times for any queue in a general Jackson Network. We also analyze the distribution of the interfeedback times in two particular models.
- **N° 342** **The abstraction process in the relational model**
 N. Spyratos, F. Bancilhon
 Nous étudions ici le problème de la traduction d'une base de données d'une représentation relationnelle en une représentation entité/relation (modèle de Chen). La méthode utilisée est celle de l'abstraction qui consiste à construire des objets complexes à partir des relations. On caractérise les traductions sans perte d'information puis les «bonnes» traductions. On donne aussi les algorithmes permettant de décider si une traduction est bonne dans certains cas spécifiques.
The objective of this paper is to study means for translating a relational representation of data into an entity/relationship one. An abstraction process is described which does this translation. Requirements for «good» abstractions are proposed and criteria for their characterization are discussed.
- **N° 343** **Une méthode d'éléments finis mixte pour les équations de Van Karman**
 Srinivasan Kesavan
 Le but de ce travail est d'adapter la méthode de Kikuchi à une formulation mixte utilisée pour approcher par éléments finis les solutions non triviales qui bifurquent à partir de la solution triviale

des équations de Von Karman. On démontre la convergence de la méthode et on obtient des estimations d'erreur.

The aim of this paper is to adapt Kikuchi's method to a mixed finite element formulation used to approximate non trivial solutions bifurcating from the trivial solution of the Von Karman equations. The convergence of the method is proved and error estimates are obtained.

□ **N° 344 Un algorithme adaptatif de balayage de Péano**

J. Quinqueton (Iria/Laboria)

Ce rapport décrit un algorithme permettant de construire un «balayage de Péano», c'est-à-dire l'application de $[0,1]^n$ dans $[0,1]$ réciproque de la célèbre «Courbe de Péano».

Ce balayage de Péano est appliqué à un ensemble de points de $[0,1]^n$ et en donne une image unidimensionnelle. De nombreuses applications de cette technique ont déjà été développées et sont présentées dans ce rapport.

This paper describes an algorithm which builds a «Peano scanning», i.e. the reciprocal mapping, from $[0,1]^n$ to $[0,1]$, of the wellknown «Peano curve».

This Peano scanning is applied to a set of points in $[0,1]^n$ and give a 1-dimensionnal image of it. Several applications of this technique have already been developped, and are presented in this paper.

□ **N° 345 Conditions nécessaires d'optimalité pour des problèmes de contrôle optimal associés à des inéquations variationnelles**

Ch. Saguez

Nous considérons un problème de contrôle optimal d'un système gouverné par une inéquation variationnelle parabolique, avec contrainte unilatérale. Sous des hypothèses de régularité suffisante, nous obtenons pour les solutions de ce problème, valeurs d'adhérence de la suite des solutions d'un problème pénalisé régularisé, des conditions nécessaires d'optimalité du même type que celles introduites par F. Mignot dans le cas elliptique.

We consider an optimal control problem of a system governed by a parabolic variational inequality with unilateral constraint. With sufficient assumptions, we obtain for the solutions, limit points of the sequence of solutions of a regularized penalty problem, optimality necessary conditions. These conditions are similar to those proved by F. Mignot in the elliptic case.

□ **N° 346 Computing integrated costs of sequences of operations with application to dictionaries**

Ph. Flajolet, J. Françon, J. Vuillemin (Iria/Laboria)

Nous introduisons une notion de coût intégré des structures de dictionnaires. Ce coût est défini comme le coût moyen d'une suite d'adjonctions, de suppressions et de consultations. Nous donnons des expressions sous forme de fractions continues des séries génératrices et nous obtenons une représentation intégrale explicite des coûts intégrés de trois implantations usuelles de la structure de dictionnaire.

We introduce a notion of integrated cost of a dictionary, as average cost of sequences of search, insert and delete operations. We express generating functions of these sequences in terms of continued fractions ; from this we derive an explicit integral expression of integrated costs for three common representations of dictionaries.

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Larson, John Leonard, "Methods for Automatic Error Analysis of Numerical Algorithms," Department of Computer Science Report No. 916, University of Illinois at Urbana-Champaign, April 1978, Ph.D. Thesis. (106 pages)

Abstract:

Using Bauer's approach to relative error propagation, methods are presented for performing various error analyses on numerical algorithms. A technique is developed which generates a system of equations employed by the error analyses, and requires an order of magnitude less time and storage than present techniques. Accurate analyses are attempted by working in the ∞ -norm, and require the solution of minimax problems. A heuristic approximation method is also described. These methods are compared with the 2-norm approximation methods of Miller.

The error analyses provide alternative criteria by which algorithms that solve the same problem may be compared. Additionally, the analysis of a composite algorithm, which is made up of concatenated sub-algorithms is given in terms of analyses done on its parts. Finally, by using a forward analysis, limited algorithm improvement is obtained by the location of sensitive operations, and the substitution of mathematically equivalent expressions.

Saylor, Paul E., "Use of the Singular Value Decomposition to Increase Execution and Storage Efficiency of the Manteuffel Algorithm for the Solution of Nonsymmetric Linear Systems," Department of Computer Science Report No. 918, University of Illinois at Urbana-Champaign, April 1978. (19 pages)

Abstract:

Optimum Chebyshev parameters may be computed dynamically by the Manteuffel algorithm for use with a generalization of Richardson's iterative method and the Jacobi semi-iterative method to solve non-symmetric linear systems. Parameters are determined by the algorithm from the convex hull of the eigenvalues of the error propagator, which the algorithm also computes by the power method. The singular value decomposition may be used to test the reliability of a simple technique to reduce execution and storage costs of the power method. The same technique also yields an inexpensive singular value decomposition making it feasible to determine precisely when to call the Manteuffel algorithm.

Gear, C. W., "Stability of Variable-Step Methods for Ordinary Differential Equations," Department of Computer Science Report No. 938, University of Illinois at Urbana-Champaign, July 1978. (13 pages)

Abstract:

It is proved that, for any multistep formula which is strongly stable at constant stepsize, there exist constants $b < 1 < B$ such that if the ratio of adjacent steps satisfies $b \leq h_n/h_{n-1} \leq B$, the variable-step implementation of the formula is stable. A practical step-order control restriction which guarantees stability is given.

Parker, Douglass Stott, Jr., "Studies in Conjugation: Huffman Tree Construction, Nonlinear Recurrences, and Permutation Networks," Department of Computer Science Report No. 930, University of Illinois at Urbana-Champaign, July 1978, Ph.D. Thesis. (209 pages)

Abstract:

This dissertation demonstrates that conjugation (the replacement, loosely speaking, of some function or computational structure F by $\phi \circ F \circ \phi^{-1}$, where $\circ$ denotes composition and ϕ is a "change of variables") is a technique that is useful in attacking the three problems listed in the title. Basically the results are, first, that the Huffman algorithm--a well-known algorithm for constructing weighted trees--produces optimal trees whenever the weight of a parent node in the tree is given by a linear, or conjugate-to-linear, function of its sons' weights, and a tree's cost is measured by a concave Schur function of the tree weights. Second, that many nonlinear recurrences (in particular, all first-order analytic iterations) may be conjugated into linear recurrences on certain domains, and hence solved quickly on a parallel machine. Third and last, that results concerning Shuffle/Exchange networks and Beneš networks (built from smaller networks using conjugating Shuffle/Unshuffle connections) can be derived from new algebraic perspectives on their structure. New control algorithms for the Beneš-type network are exhibited which are asymptotically faster than previously known ones, but unfortunately are not good enough to be practical. Equivalence between three variants of the Shuffle/Exchange network is then proved, giving as a by-product an elegant Fast Fourier Transform algorithm which produces outputs in correct order without the normally required bit-reversal permutation of the data, and it is then shown that only $4 \log_2 N$ Shuffle/Exchange passes is sufficient to generate any permutation of N lines, which is surprising since implementation of a Batcher network requires $(\log_2 N)^2$ passes.

Plaisted, David A., "Well-Founded Orderings for Proving Termination of Rewrite Rules," Department of Computer Science Report No. 932, University of Illinois at Urbana-Champaign, July 1978. (35 pages)

Abstract:

Well-founded partial orderings can be used to prove the termination of programs, and can also be used for algebraic simplification. A new class of well-founded orderings is presented which can be used to prove the termination of programs expressed as sets of rewrite rules. The orderings are syntactically defined in terms of a lexicographic ordering and an ordering on multisets and require an ordering on the function and constant symbols to be specified. This technique of proving termination appears to be of practical importance, because it is able to handle rewrite rules that arise from typical recursive programs. Several efficient algorithms are presented which allow the termination of a set of rewrite rules to be verified in linear time, in cases to which this method applies. These results can be viewed in terms of an incomplete system of logic in which short termination proofs exist. The well-founded orderings may also be useful for proofs by mathematical induction in various areas of mathematics. A general characterization of a class of rewrite rules is presented, for which termination can be proved using these orderings.

Friesen, Donald Kent, "Sensitivity Analysis for Heuristic Algorithms," Department of Computer Science Report No. 739, University of Illinois at Urbana-Champaign, August 1978, Ph.D. Thesis. (182 pages).

Abstract:

Sensitivity analysis is an important aspect of many optimization problems and has been extensively studied in relation to optimal solutions. In this thesis, the concept of sensitivity analysis is applied to near-optimal solutions. In particular, approximate solutions to bin packing, multiprocessor scheduling and knapsack problems are examined, and the effect of varying certain parameters of these problems on the approximation algorithm is analyzed.

Hansche, Brian Alfred, "An Implementation of a System for the Formal Definition of Programming Languages," Department of Computer Science Report No. 935, University of Illinois at Urbana-Champaign, August 1978, Ph.D. Thesis. (25 pages)

Abstract:

This paper describes a method for generating a table-driven interpreter for a programming language from a formal specification of its syntax and semantics. Such interpreters would be useful in verifying the correctness of formal specifications, and in providing experience with initial versions of experimental languages. The paper discusses existing formal specification methods and selects one method, based on a string replacement mechanism, as the basis for implementing a table-driven interpreter. A class of machines called Parse Tree Automata is defined. These machines are such that each state can be represented as a parse tree of a concrete program. An interpreter is then defined by a computation sequence of the Parse Tree Automaton. A method of constructing a table-driven interpreter based on these abstract machines is given and algorithms for reducing the number of transitions needed by the interpreter are supplied. The paper also includes a method of verifying that the formal specification is complete, well formed, and not redundant.

Petzold, Linda Ruth, "An Efficient Numerical Method for Highly Oscillatory Ordinary Differential Equations," Department of Computer Science Report No. 933, University of Illinois at Urbana-Champaign, August 1978, Ph.D. Thesis. (132 pages)

Abstract:

A "quasi-envelope of the solution of highly oscillatory differential equations is defined. For many problems this is a smooth function which can be integrated using much larger steps than are possible for the original problem. Since the definition of the quasi-envelope is a differential equation involving an integral of the original oscillatory problem, it is necessary to integrate the original problem over a cycle of the oscillation (to average the effects of a full cycle). This information can then be extrapolated over a long (giant!) time step. Unless the period is known a priori, it is also necessary to estimate it either early in the integration (if it is fixed) or periodically (if it is slowly varying). Error propagation properties of this technique are investigated, and an automatic program is presented. Numerical results indicate that this technique is much more efficient than conventional ODE methods, for many oscillating problems.

Skeel, Robert D., "Equivalent Forms of Multistep Formulas," Department of Computer Science Report No. 940, University of Illinois at Urbana-Champaign, August 1978. (42 pages)

Abstract:

For uniform meshes it is shown that any linear k -step formula can be formulated so that only k values need to be saved between steps. By saving an additional m values it is possible to construct local polynomial approximations of degree $k+m-1$, which can be used as predictor formulas. Different polynomial bases lead to different equivalent forms of multistep formulas. In particular, local monomial bases yield Nordsieck formulas. An explicit one-to-one correspondence is established between Nordsieck formulas and k -step-formulas of order at least k , and a strong equivalence result is proved for all but certain pathological cases. Equivalence is also shown for $P(EC)*$ formulas but not for $P(EC)*E$ formulas.

Gear, C. W., "Runge-Kutta Starters for Multistep Methods," Department of Computer Science Report No. 938, University of Illinois at Urbana-Champaign, September 1978. (38 pages)

Abstract:

Runge-Kutta-like formulas are presented which enable a multistep method to start or restart at a high order after just one RK step. These greatly improve the efficiency of multistep methods in one situation in which they were previously outperformed by RK methods--problems with frequent discontinuities or sudden large increases in derivatives, either of which cause an automatic program to reduce order and stepsize suddenly.

Plaisted, David A., "A Recursively Defined Ordering for Proving Termination of Term Rewriting Systems," Department of Computer Science Report No. 943, University of Illinois at Urbana-Champaign, September 1978. (54 pages)

Abstract:

A new ordering on terms is defined and its properties are presented. This partial ordering is well-founded and appears to be useful for proving termination of commonly occurring systems of rewrite rules. It also appears useful for general algebraic simplification routines, and for mechanical theorem proving programs dealing with equality. In previous work, the author presented a similar ordering which could not prove termination of systems of rewrite rules containing the distributive law $x * (y+z) \rightarrow x*y + x*z$. This new ordering, called the "path of subterms" ordering, can handle the distributive law and many similar replacements, together with replacements like those the former ordering could handle. The path of subterms ordering is syntactically defined and requires a total ordering on function and constant symbols to be specified. An $nlogn$ algorithm for computing the ordering on ground terms is given. Less efficient algorithms for computing the ordering on a subclass of the pairs of non-ground terms are also given. A characterization of a fairly general class of replacements which the path of subterms of rewrite rules for which termination can be proven using this ordering are given. Also, this ordering has an interesting relationship to the class of primitive recursive functions.

Perl, Y. and Zaks, S., "Deficient Generalized Fibonacci Maximum Path Graphs," Department of Computer Science Report No. 947, University of Illinois at Urbana-Champaign, November, 1978. (34 pages)

Abstract:

The structure of an acyclic directed graph with n vertices and m edges, maximizing the number of distinct paths between two given vertices, is studied. New techniques for solving this problem are developed, thus enabling us to extend previous results.

Speelpenning, B., "The Generalized Element Method," Department of Computer Science Report No. 946, University of Illinois at Urbana-Champaign, November, 1978. (11 pages)

Abstract:

This paper presents a new method for solving large, sparse symmetric systems of equations derived from networks. The method is particularly suited to networks arising from using the finite element method. The main characteristics of the method are its homogeneity and efficiency. Homogeneity allows for automatic substructuring, interrupt and restart facilities, all completely controlled by the elimination sequence of the nodes. For each elimination sequence, minimal operation count is achieved. The amount of I/O can be controlled to a certain extent. The generalized element method has evolved from a new interpretation of the wavefront method. It may be used adaptively in combination with such methods as the hypermatrix method to optimize the use of available core.

Zaks, S. and Perl, Y., "On the Complexity of Edge Labeling for Trees," Department of Computer Science Report No. 948, University of Illinois at Urbana-Champaign, November, 1978. (25 pages)

Abstract:

Given a tree T with n edges and a set W of n weights, we deal with labelings of the edges of T with weights from W , optimizing certain objective functions. For some of these functions the optimization problem is shown to be NP-complete (e.g., finding a labeling with minimal diameter), and for others we find polynomial-time algorithms (e.g., finding a labeling with minimal average distance).

Gajski, Daniel D., "An Algorithm for Solving Linear Recurrence Systems on Parallel and Pipelined Machines," Department of Computer Science Report No. 953, University of Illinois at Urbana-Champaign, December, 1978. (35 pages)

Abstract:

A new algorithm for the solution of linear recurrence systems on parallel or pipelined computers is described. Time bounds, speedup and efficiency for SIMD and MIMD computers with fixed number of processing elements as well as for pipelined computers with fixed number of stages per operation are obtained. The model of each computer is discussed in detail to explain better performance of the pipelined model. A simple modification in the design of processing elements for parallel computers makes parallel model superior.

Plaisted, David A., "Inference Rules for Unsatisfiability," Department of Computer Science Report No. 955, University of Illinois at Urbana-Champaign, January, 1979. (18 pages)

Abstract:

There are some relationships between unsatisfiability of sets of clauses and properties of polynomials in several variables. These polynomials can be used to obtain a polynomial time solution to a certain problem involving sets of clauses. Using these polynomials, one can establish a correspondence between unsatisfiable sets of clauses and a convex region of Euclidean space. Also, some inference rules based on these polynomials may provide shorter proofs of inconsistency than are possible using other known inference rules.

Plaisted, David A., "Theorem Proving with Abstraction, Part I," Department of Computer Science Report No. 961, University of Illinois at Urbana-Champaign, February, 1979. (54 pages)

Abstract:

A class of mappings called abstractions are defined, and examples of abstractions are given. These functions map a set S of clauses onto a possibly simpler set T of clauses. Also, resolution proofs from S map onto possibly simpler resolution proofs from T . In order to search for a proof of a clause C from S , it suffices to search for a proof from T and attempt to invert the abstraction mapping to obtain a proof of C from S . Some theorem proving strategies based on this idea are presented. Most of these strategies are complete. A method of using more than one abstraction at the same time is presented in Part II. This requires the use of "multiclauses," which are multisets of literals, and associated "m-abstraction mappings" on multiclauses. Certain abstractions are especially interesting, because they correspond to particular interpretations of the set S of clauses. The use of abstractions permits the advantages of set-of-support strategies to be realized in arbitrary complete non set-of-support resolution strategies.

Schell, Richard M., Jr., "Methods for Constructing Parallel Compilers for Use in a Multiprocessor Environment," Department of Computer Science Report No. 958, University of Illinois at Urbana-Champaign, February, 1979, Ph.D. Thesis. (214 pages)

Abstract:

This thesis explores methods for adapting compiler technology to produce compilers written as a set of concurrent processes, to be used in multiprocessor environments. The thesis provides a model for parallel compilers based on replication of processes and discusses method of implementing the model.

In particular, several new techniques are presented. A method for performing parallel lexical analysis is given. The method is based on a two-phase scanner. A technique for parallel parsing, piecewise LR parsing, is developed and coupled with a scheme for parallel syntax error recovery. A new family of attribute grammar evaluators is presented. These evaluators, parallel treewalk evaluators, can be used to provide parallelism in the semantic analysis and translation phases of compilation.

Plaisted, David A., "Theorem Proving with Abstraction, Part II," Department of Computer Science Report No. 965, University of Illinois at Urbana-Champaign, March, 1979. (50 pages)

Abstract:

The concept of an abstraction was defined in Part I of this paper, and some theorem proving strategies based on abstraction were presented. The basic idea is to use the solution of a simple "abstracted" problem as a guide to the solution of a more complicated problem. This idea was formalized to yield a wide class of complete theorem proving strategies for the first-order predicate calculus. In Part II, m-abstractions are defined, and their advantages are discussed. They operate on "multiclauses," which are multisets of literals. Several elegant strategies based on m-abstractions are presented. Next, bounded multiclauses are introduced, together with abstractions on them. These have most of the advantages of ordinary multiclauses, but restrict the size of the abstracted search space more. All strategies considered in Part II are complete. Finally, some new classes of abstraction and m-abstraction mappings are presented.

Gear, C. W., "Initial Value Problems: Practical Theoretical Developments," Department of Computer Science Report No. 962, University of Illinois at Urbana-Champaign, March, 1979. (36 pages)

Abstract:

This paper surveys several recent developments in the theory of multistep initial value solvers that are useful for the implementation of practical codes. These developments are concerned with stability of variable step/order methods, starting at a high order (and hence, with a large step), and the integration of problems with rapidly oscillating solutions. This paper was presented at the IMA Conference on the Numerical Solution of Differential Equations, Manchester, England, December 19, 1978.