colloquium numerieke wiskunde

najaarssemester 1983 / voorjaarssemester 1984

de praktijk van de numerieke wiskunde

Centrum voor Wiskunde en Informatica

DE PRAKTIJK VAN DE NUMERIEKE WISKUNDE

Numerieke Wiskunde Colloquium 1983/1984

De afdeling Numerieke Wiskunde van het Centrum voor Wiskunde en Informatica (CWI)* organiseert een colloquium waarin de praktische beoefening van numerieke wiskunde centraal komt te staan. Het colloquium is erop gericht beoefenaren van de numerieke wiskunde bijeen te brengen die deze tak van de wiskunde op enigerlei wijze gebruiken bij het oplossen dan wel bestuderen van concrete praktijkproblemen. Hierbij wordt in het bijzonder gedacht aan diegenen die werkzaam zijn in het Nederlandse bedrijfsleven en bij instellingen waar het concrete praktijkprobleem centraal staat. Het hoofddoel van het colloquium is derhalve de praktische beoefening van de numerieke wiskunde te belichten alsmede het belang hiervan voor het Nederlandse bedrijfsleven. Gebruikers van numerieke wiskunde uit andere disciplines worden uitgenodigd het colloquium te volgen. Met name voor deze gebruikers kan het colloquium een brugfunctie vervullen tussen theorie en praktijk.

Verdere gegevens

Het colloquium staat onder leiding van Prof.dr. P.J. van der Houwen en Dr. J.G. Verwer. Het vindt om de twee weken plaats op vrijdagmiddag van 14.15 tot 16.00 uur in zaal Z 010 van het Centrum voor Wiskunde en Informatica (zie rooster) Achterin deze brochure is een plattegrond opgenomen van de omgeving van het Centrum voor Wiskunde en Informatica met aanwijzigingen voor het openbaar vervoer.

Deelname aan het colloquium is gratis; aanmelding is niet nodig.

Voor nadere inlichtingen kan men zich wenden tot het secretariaat van het Centrum voor Wiskunde en Informatica (Mw. W. van Eijk, tel. 020-592 4058) of tot de organisatoren Prof.dr. P.J. van der Houwen, tel. 020-592 4083, en Dr. J.G. Verwer, tel. 020-592 4096.

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CWI

Centrum voor Wiskunde en Informatica

Om in de aanduiding van haar instituut het karakter van de totaliteit van activiteiten op het gebied van wiskunde en informatica, beter dan tot nu toe, tot uitdrukking te laten komen, heeft de Stichting Mathematisch Centrum de naam van haar instituut MC gewijzigd in 'Centrum voor Wiskunde en Informatica' (afgekort CWI).

4 november 1983 A.O.H. Axelsson (Katholieke Universiteit Nijmegen)
"On the numerical solution of large scale flow problems"

In principle, linear and nonlinear structural mechanics and many fluid flow problems can be solved by existing finite element methodology. However, if the finite element equations system is very large, the storage requirements and computational cost involved may preclude actual solution.

Take as an example a calculation of a three-dimensional flow problem in which $n^3 = 32^3$ mesh-points are employed. At every node there are 4 degrees of freedom (velocities and pressure). Just the storage of the corresponding (simplest) nonsymmetric finite element matrix would require about $(4n)^5 \simeq 3 \times 10^{10}$ words of storage if a bandsolver is used. This is clearly outside the realm of consideration on any computer.

Recent trends suggest the potential of supercomputers because of their significant CPU-speed advantages for vectorizable operations over previous generations of scientific computers. However, two problems still remain unsolved.

One problem is that direct solution techniques besides factorization involves backward and forward solution of two triangular systems. But this is a sequential process and hence not directly amenable to vectorization. The same is true for the classical incomplete factorization techniques. Some attempts to overcome this by use of Neumann series or some similar approximation of the inverse has been taken. But there is then an increased cost in the numbers of iterations, which is related to the second problem.

The second problem has to do with I/O (i.e. disk file read/write) costs, which have not dropped by the introduction of supercomputers and it is I/O which is the major cost factor of large scale finite element problem solvers. Hence methods with few I/O calls are needed.

We discuss various methods to overcome these problems by use of iterative methods for which the matrix is stored on compact form and hence doesn´t need more storage than a few vectors of unknowns:

1. Block incomplete factorization methods coupled with generalized conjugate gradient acceleration methods.

2. Approximate inverse methods based on inverses of superelement matrices and coupled with CGT methods (conjugate gradient Tschebyscheff methods).

We show that the number of iterations and hence the number of I/O calls of the above methods compare favourably with those needed for direct methods. To keep the storage down even further we also consider methods based on recalculating matrix coefficients. The considerations are valid both in "scalar" as well as in "vector" mode.

J.W. Boerstoel, A. Kassies (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam)
"Integrating multigrid relaxation into a robust fast-solver for transonic potential flows around lifting airfoils"

A robust fast-solver for the calculation of transonic potential flows around lifting airfoils is presented. The solver is a combination of Newton iteration and CS (correction scheme) multigrid relaxation. This combination allows a simpler analysis of convergence properties than the FAS (full approximation storage) multigrid relaxation that is usually applied, and was selected for this reason. The solver has been implemented in the NLR code TRAFS and has been extensively tested numerically.

Three new salient features are required to make the fast solver really effective. The circulation in the asymptotic far-field solution is computed by a procedure based on Newton iteration applied to the Kutta condition. In order to exclude rigorously shocks and to reduce as much as possible artificial viscosity in shocks and the associated stiffness effects (these effects hamper fast Newton-iteration convergence), upwinding based on mass-flux-vector splitting was introduced.

At linear stages of the algorithm, velocity overshoots and corresponding potential jumps at shocks are allowed. These are usually generated by large long-wavelength solution corrections. It is shown that these jumps also arise in other algorithms than that of TRAFS. The potential jumps are translated here in corresponding shock-position updates by a simple and cheap linear extrapolation technique in potential distributions. Results of numerical experiments illustrate these features.

The TRAFS algorithm is shown to be at least competitive to existing FAS multigrid algorithms, and is at this moment equally fast as very efficient AF algorithms. It can compute subsonic and transonic potential flows around lifting airfoils in 8-25 work units.

*) The results presented form part of AIAA paper 83-1885.

18 november 1983

R.H.J. Gmelig Meyling (Universiteit van Amsterdam)
"Least-squares B-spline surface reconstruction in tomography"

An important issue in tomography is the reconstruction of a closed 3-d surface from data given at different photo-levels. Medical interest in the process of growth requires an accurate and smooth surface approximation of human organs (e.g. eye, placenta, tumour).

The reconstruction of 3-dimensional objects, which can be expressed in spherical coordinates, is equivalent to the approximation of a one-valued function, defined on a rectangular grid.

Tensor product cubic B-splines offer second-order derivative smoothness and small overall curvature of the surface, compared to other approximation techniques, which is favourable in view of the natural behaviour of the biological material.

Boundary conditions are essential to impose periodicity of the solution and correct derivative-values at the upper- and lower-pole singularities of the coordinate transformation.

A weighted least-squares method is used to eliminate data errors, due to digitalisation of the surface contours.

Some interesting applications of the developed B-spline algorithm are:

- calculation of the outward directed normal vector (generation of shaded pictures).
- plotting the intersection of the surface with an arbitrary plane.
- volume-calculation of the 3-d object.
- data-reduction (database with knots and B-spline coefficients, instead of the original data).

J.P. Hollenberg (Rekencentrum Rijksuniversiteit Groningen)
"Working with vector computers"

Improvements in technology have been insufficient - by themselves - to produce the arithmetic performance that is required to solve certain challenging large problems. In order to speed up computation the designers of modern day super computers use parallelism. One form of parallelism is pipelining. As will be explained, in pipelining the required numbers are manufactured like on an assembly-line. This method is effective when applied to a sequence

of identical operations, as occur during working with vectors of numbers. The two brands of highly pipelined vector machines, which are commercially available (the CYBER 205 and the CRAY) will be briefly discussed. Furthermore, the impact of this type of architecture on the choice of algorithms and their programming will be illustrated, mainly by examples.

2 december 1983 H. Akse (Landbouwhogeschool Wageningen)
"Gas-solid adsorption simulation"

Adsorption of one or more components form gaseous mixtures is a typical class of transient chemical- and environmental engineering processes.

Removal of undesired components from a gaseous stream takes place in a fixed-bed of porous adsorbent particles. Fixed-bed adsorbers for such purposes present a frequent but difficult problem for process engineers.

Apart from the assessment of a cyclic process of adsorption and desorption the mathematical modelling of the physical phenomena is rather difficult and complicated.

The set of partial differential equations containing the mass- and heat balances of the system is far from lineair in character. In the literature numerical solutions are found for such a set of differential equations using the Runga-Kutta or modified Euler discretization procedures. Such procedures, however, are of the explicit type. For the system under consideration this will mean that rather large computation times are needed. Even the explicit Cranck-Nicholson discretization procedure needs too much computer time for this system and therefore is too expensive for frequent use in a technical context.

Besides the necessity of reducing the complexity of the system, without loosing sight of the reality, a fast algorithm is needed in order to reduce both computation time and computation costs.

In co-operation with the Centre for Mathematics and Computer Science a new procedure is set up using an implicit scheme following the Newton Raphson procedure.

The reduction of computation time and costs compared with those of the above mentioned procedures is considerable, while the differences in the results for either of the procedures are very small.

M. Bakker (Centrum voor Wiskunde en Informatica, Amsterdam)
"Numerical solution of a one-dimensional Stefan problem arising from laser-annealing"

The variation of temperature of laser-irradiated silicon is given by a two or three phase Stefan problem in one dimension [1] . In this abstract, we confine to the two phase problem.

The two phase problem is described by the initial boundary problem

$$c\rho\frac{\partial T}{\partial t} = \frac{\partial}{\partial z}(\kappa(T)\frac{\partial T}{\partial z}) + S_L(z,t), t > 0;\ z \in (0,z_0);\ z \neq s(t);$$

$$S_L(z,t) = \alpha(z,T)I_0(1-R)e^{-(\frac{t-t_0}{h})^2-\alpha(z,T)z};$$

$$\frac{\partial T}{\partial z}(0,t) = 0;\ T(z_0,t) = T(z,0) = T_0\ (= 300^0K);$$

where T(z,t) is the temperature of the silicon, s(t) is the melt front (i.e. the interface between the solid and liquid state) and c, ρ, ,I_0, t_0, h, z_0, R are positive parameters, $0<R<1$ and the conductivity $\kappa(T)$ and the absorption coefficient $\alpha(z,T)$ are positive. The melt front s(t), if present , is governed by the *ordinary* differential equation

$$T(s(t),t) = T_m\ (= 1685^oK), \text{ if } T(0,t) > T_m;$$

$$L_0\rho\frac{ds(t)}{dt} = [\kappa(T)\frac{\partial T}{\partial z}]_{z=s(t)^-}^{z=s(t)^+}$$

The problem is solved in two steps:

a) By introducing the new variables x and τ defined by

$$t = \tau;$$

$$z = \begin{cases}(1-x)z_0 + xs(t) & ;\ \text{if } s(t) \leq z \leq z_0;\\ xs(t) & ;\ \text{if } z \leq s(t);\ x \in (0,1)\end{cases}$$

one obtains a system of two partial differential equations (for T_L ,the liquid state temperature and for T_S , the solid state temperature) and one ordinary differential equation (for the melt front speed). The two PDEs are defined on a domain of *fixed* length (the interval [0,1]).

b) by a combination of the backward Euler method and some semidiscretization of the space variable, this system of differential equations is numerically solved.

For the last step, an iteration scheme is used which is roughly analog to the method of Bonerot and Jamet [2].

References

[1] Z.L. Wang and F. W. Saris, *A Thermal-Melting-Model Calculation of Pulsed Laser Annealing of GaAs,* Physics Letters **83A** (1981), 367-370;

[2] R. Bonerot and P. Jamet, *A Second Order Finite Element Method for the One-Dimensional Stefan Problem,* Internat. J. Numer. Methods Engrg. **17** (1974), 811-820;

16 december 1983 B.J. Braams (FOM instituut voor Plasmafysica, Nieuwegein)

"Numerical modelling for a transport problem in plasma physics"

An important problem in plasma physics for nuclear fusion is how to extract from the magnetic confinement device the large amounts of energy and

alpha particles which are produced in the inner plasma. In the interior of the toroidal confinement region the main transport process is diffusion across magnetic surfaces, while near the edge it is the flow along those fieldlines that intersect a material boundary. Both these processes have in the past been modelled by one-dimensional transport codes, which for the radial diffusion problems in particular have become highly sophisticated.

The subject of this presentation is two-dimensional modelling of the edge plasma region, in which both the radial diffusion of particles and energy and the convection and conduction along the fieldlines are important processes. The fluid code which has been developed for these studies is based on a finite volume discretization of the conservation equations on a topologically rectangular mesh, using methods of D B Spalding's school. The discretization is fully implicit in time with the aid of an elliptic pressure correction procedure, and the discretization coefficients move continuously from an upwind scheme for high grid Peclet number to a central difference scheme at low Pe. This code has been applied to provide qualitative productions about the edge plasma in present and future experiments.

*) Work performed at: UKAEA Culham Laboratory, England and (present address) MPI für Plasmaphysik, 8046 Garching bei München, West Germany

H. de Bruijn & I. Kuijper (B.V. Neratoom, Den Haag)
"Least squares numerical analysis of the steady state and transient thermal hydraulic behaviour of LMFBR heat exchangers"

The numerical method, developed in this paper, is characterized by the following features:

1. the construction of elements in space and time, all being members of the isoparametric quadrilateral family with reduced and partially upwind integration;

2. a matrix representation for the differential operators, which enables a very efficient coding of the differential equations governing the problem;

3. an automatic scaling procedure, which ensures that the global equations of the problem will be optimally conditioned;

4. a least squares finite element procedure, resulting in a global matrix which is positive definite and symmetric.

The numerical method has been succesfully applied to analyse three-dimensional, cylindrically symmetric flow and heat transfer in a heat exchanger.

To describe the complex transport phenomena in the flow around the tubes, use has been made of a "liquid-tube continuum" approach, with continuously distributed flow resistance and heat transfer mechanism. This analysis leads to several different sets of first order partial differential equations. They are all solved with the same kind of element, and with the same Least Squares (L.S.FEM) programming package.

It will be argued that, at least for these kind of problems, L.S.FEM is the simplest possible numerical method. It will furthermore be proved that the method is $O(h^2)$ consistent, unconditionally stable, well-conditioned, and competitive with respect to computing time and memory requirements. But, most of all, it is uniquely compatible with conventional finite differences and finite elements, the tremendous advantage of which will be demonstrated by some useful examples.

13 januari 1984 W. Zijl (TNO, Delft)
"Transport of waste heat or pollutants in the suboil"

The last decade has witnessed rapid progress in the development of computer-based models for the simulation of subsurface fluid motion. Well-known are reservoir simulation models for economically predicting the response of an oil- or gas producing reservoir to a variety of operating conditions or development plans.

In a similar way transport of pollutants and waste heat in a subsurface flow system can be predicted, being an important tool for management and licensing purposes.

Underground motion of oil, gas and water is conveniently calculated with finite difference methods using one-, two-, or three-dimensional grids, and vector computers are often used to solve the resulting system of large matrix equations.

In this paper some applications of the so-called SWIP-code will be demonstrated in the field of i) aquifer thermal energy storage and ii) transport of pollutants from a waste disposal site.

Emphasis will be laid upon appropriate modelling of these above described geohydrologic problems. The detailed structure of the permeability-porosity

patterns in a reservoir are the result of long and complex histories of geologic evolution. The combined processes of deposition, burial, compaction, diagenesis, and structural deformation, yield final reservoir bodies of widely varied geometries, permeability-porosity characteristics, and structural configurations that are difficult to predict, but that are necessary as input data in the computer code. Some ways to deal with these difficulties will be discussed.

G.L.M. Augenbroe (Technische Hogeschool Delft, vakgroep Bouwfysica)
"Temperature calculations in buildings"

Mainly due to the interest that energy conservation measures and use of solar energy have been receiving in recent years temperature calculations in buildings is a field of growing importance. Also the assessment of comfort requirements and the investigation into control strategies for air condition and active solar energy equipment often necessitate calculation of the non-stationary temperature distribution within the building.

Obviously one of the main problems in this area is constituted by the fact that a building, or even a single house for that matter comprises a large number of components of which many are physically interrelated in some way or another. Moreover an accurate modelling of heat transfer phenomena at component level can require the use of a set of coupled and sometimes nonlinear partial differential equations in complex geometries. For a building containing several of these components a very large problem would result.

One way to avoid this is to perform a separate investigation at the single-component level, using a flexible and sophisticated finite element program as for instance AFEP. The results are consequently used to develop fairly simple components models, i.e. of considerably reduced order and preferably "expressable" into simple one-dimensional finite elements, in accordance with the "lumped" heat exchange equations. Sometimes one might prefer additional experimental data to obtain or validate the simple model.

For the ensuing calculations on building-scale the AFEP-related computer package BFEP also consisting of a (yet much smaller) library of FORTRAN-coded subroutines was developed.

It must be noted that even without preliminary investigations most components can be modelled straighforwardly, whereas due to modest accuracy requirements the discretization can be chosen to be

rather coarse.

What we are primarily left with then is the problem of discretizing the convective and radiative heat exchanges that occur between different components. Also much attention must be given to establishing the heat loads resulting from solar irradiation, man, machines, heat plants, etc. These loads can be built by separately developed subroutines, most of which calculate the node-loads directly without taking recourse to the usual element-assembly process.

Due to its modular approach, the user can define any load, climate, control etc. in a user-written main program and in user-subroutines. Alternatively the user can simply select standard options by supplying appropriate input data. The actual BFEP computation stage is preceded by a separate preparation stage during which data-generating subroutines can be activated.

It is shown that the major feature of BFEP as opposed to related programs is that the user has to perform his own modelling tasks prior to any calculations. On the other hand this modelling-facility guarantees maximum flexibility and use in almost unlimited areas.

An example from the realm of the use of solar energy is presented.

27 januari 1984

F. Jacobs (Kon./Shell Exploratie en Productie Laboratorium, Rijswijk)

"Numerical problems in the simulation of flow through oil/gas reservoirs"

With the increase in number and complexity of recovery processes on the one hand and on the other hand the decrease of economical margins, which requires many alternatives to be studied, nowadays numerical reservoir simulation has become the major tool in the oil/gas industry for predicting the outcome of field production proposals.

Besides on the reliability of the flow and phase equilibrium models and of the geological and petrophysical data that are used, the accuracy of a prediction mainly depends on the quality of the numerical discretization involved.

After an introduction of the general oil/gas reservoir flow model and a mathematical characterisation of its most important aspects, the discussion will focus on

1. the tracking of steep profiles in concentrations (shocks)

2. the adaptive construction of discretization grids combined with effective multigrid methods for solving the final linear algebraic equations.

A.J. van der Wees (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam)
"Robust calculation of 3D transonic potential flow based on the non-linear FAS multigrid method and a mixed ILU/SIP - algorithm" *)

A mixed incomplete lower upper decomposition/strongly implicit procedure (ILU/SIP) relaxation algorithm is investigated within a non-linear FAS multigrid research code. The algorithm is designed to be fast, robust (stable convergence for all local flow directions) and insensitive (good short wave damping for all possible mesh ratios). The algorithm involves only one free parameter. Numerical results will be presented for a transonic model disturbance equation solved for the flow in "a windtunnel with a bump on the bottom".

*) The results presented form part of AIAA 83-1950.

10 februari 1984 C. Flokstra (Waterloopkundig Laboratorium, Delft)
"A mathematical model for the computation of 2-D bed levels in a river"

The modelling of the time-dependent development of a river bed induced by the occurring sediment transport will be discussed for the case of dominant bed load transport. A two-dimensional description of the bed is used to predict the cross-sectional bed level distribution in a river bend.

The fluid motion is modelled by the depth-averaged equations of motions accounting for some 3-D flow effects. The sediment transport is determined by the use of a standard sediment transport formula adapted for the effects of a non flat bed and the spiral motion of the flow. The interaction between the flow and bed is included in the model.

Attention will be paid to the mathematical implications of the system of resulting equations and the required boundary conditions. The numerical solution of the system is obtained by a quite straightforward approach.

A number of model tests have been carried out with a physical model to check the results of the

mathematical model.

G.K. Verboom (Waterloopkundig Laboratorium, Delft)
"Weakly-reflective boundary conditions for the shallow water equations"

The flow in rivers, estuaries and coastal seas can adequately be described for a number of engineering problems by the one and two dimensional shallow water equations. For this the flow must be nearly horizontal and more or less homogeneous in the vertical. Viscous terms may arise in the momentum equations due to averaging the equations over the turbulent fluctuations and/or over the vertical. If these viscous terms are neglected the equations are known to be strictly hyperbolic. If these equations are applied to mixed initial-boundary value problems, as most of our practical problems are, we must prescribe initial conditions for all variables and a specific number of boundary conditions at each part of the boundary.

In most problems the area of interest is part of a larger system to which it is connected by open boundaries. In nature these boundaries do not exist and disturbances can cross them unhampered in both directions; in our numerical model we must include this property explicitely. Disturbances are generated in the modelling process because the usually measured boundary conditions are not exact, the numerical model itself is not exact, and most of all due to engineering measures the influence of which are to be studied.

In recent literature so-called non- or weakly-reflective boundary conditions are derived for one and two dimensional hyperbolic equations. For systems of linear equations with constant or variable coefficients the theory seems to be well developed, but for quasi-linear equations there is few literature, and a number of questions is still to be answered.

In this lecture weakly-reflective boundary conditions are derived for the one- and two-dimensional strictly hyperbolic shallow water equations. Special attention will be given to the numerical implementation and to the influence on the stability of the solution procedure as a whole. Results will be presented which are obtained with a finite difference and a finite element method.

24 februari 1984

R. de Bruin (Rekencentrum Rijksuniversiteit Groningen)
"Some software for graph theoretical problems"

The theory of graph analysis is rather extensive and the demand for routines treating graph theoretical problems is considerable. Nevertheless such routines are not widely offered in general program libraries.

Discussed is some software which seems to cover the bulk of the need of the users.

- GRADAP, a simple package which is frequently used in social sciences. It has however a wider field of application.

- NETWERK, a routine intended to accompany a project for which a network planning is present. Relations with PERT will be discussed.

- An algorithm for the acyclic subgraph problem.

C.G. van der Laan (Rekencentrum Rijksuniversiteit Groningen)
"Numerical mathematics in practical data fitting"

A few examples of problems arising from practical situations, where splines are used, will be discussed. The problem situations are:

- separation of exponentials

- determination of growth curves

- cleaning of stellar maps

In all these cases the numerical aspects are a vital but small part: the totality of numerical mathematics, statistics, graphics and software engineering are needed.

9 maart 1984

A. Kooistra (IWIS-TNO, Den Haag)
"Fast solution of linear equations with sparse system matrices"

The dynamical behaviour of linked mechanical systems being frequently used in crash victim simulation may be given by the set

$$S\ddot{q} = b$$

of ordinary differential equations (ode's). S is called the system matrix and b the power vector. The vector q, which has to be solved, represents the translation of the centre of the system and the rotations of the member elements of the system. Thus defining the whole movement of the system.

In the course of time S and b will be changing and so will q. On solving the set of ode's, by a

numerical process, sets of linear equations of the form Sx = b are to be solved many times. The velocity of the solving process depends for a great deal on how quickly Sx = b is solved again and again. Now S has elements which are zero for sure. The structure of S,i.e. the pattern of zero elements, depends only on the structure of the mechanical system and on its description. It is obvious that a solution method exploiting this structure will be much faster then the traditional ones. Such a method is designed and will be discussed.

Also a strategy will be given to find the optimal way of description of the mechanical system; optimal in the sense of speed of solving the set Sx = b.

G. de Mey, D. Loret and A. van Calster (Universiteit van Gent)
"Modelling of D-MOS transistors"

The D-MOS transistor is a semiconductor component designed as a switching device, i.e. it can be either in a high conducting state (called "on") or a non-conducting state ("off"). In the "on" state, the transistor should be able to conduct a large electric current with a negligible voltage drop. In the "off" state, the current is almost zero, but the transistor should be able to withstand a high voltage across its terminals. For practical purposes, this voltage should be as high as possible, which means high electric field inside the semiconductor. However, the maximum field inside the transistor should never exceed the ionidation level. The purpose of the present study, in collaboration with Bell Telephone Antwerp, was to design an optimal transistor geometry in order to get the highest possible terminal voltage. In order to calculate the field distribution, the Poisson equation has been solved numerically using the boundary element method. This numerical technique is extremely useful if the device geometry is a variable input parameter. It was found that the terminal voltage can vary over one order of magnitude only by changing the device geometry.

23 maart 1984

J.L.O. Vranckx (Agfa-Gevaert, Mortsel, België)
"Two-dimensional spectral analysis in the evaluation of image quality of photographic materials"

The image quality of a photographic system is determined by the quality of the signal reproduction (the image) and by the noise superimposed on this signal. Both properties, i.e. signal reproduction and

noise, are usually measured separately and not always in comparable circumstances, whereafter they are combined to a signal-to-noise ratio for use as a definite measure for the performance of the photographic system.

We have now developed a method for determining this signal-to-noise ratio by one single measurement. We use the two-dimensional Fourier Transform and two-dimensional cross-correlation for determining the power spectra (also called Wienerspectra) of both signal and noise. From these spectra we then calculate the signal-to-noise ratio.

Up to now this method was only applied for the evaluation of radiographic systems; there is however no reason why other photographic systems could not be evaluated using this method. Moreover the method is also applicable for non-photographic imaging systems. For noise reduction by digital image processing techniques it is very important to have a good estimate of the noise power spectrum. Our method not only gives us this spectrum for the noise but also for the signal, which brings us to a good starting position to go into the field of image enhancement.

S. Polak, C. den Heijer (Philips, Eindhoven)
"Programpackage for PDE problems"

The Philips Mathematical Software group developes, maintains and supports packages for the analysis of continuum physics problems. Such problems are e.g. magnetic and electric potential problems, eddy current problems, heat transfer problems, etc. In the MSW group a number of packages have been developed for such problems (MAGGY, PADDY, SEMMY, TEDDY, etc.). The main topic at this moment is the analysis of semiconductor problems.

The packages contain on one hand algorithms for solution of the partial differential equation involved, on the other hand software for the translation of the user oriented problem definition into algorithm parameters and for the display of results.

In this lecture we shall discuss the algorithmic aspects as well as the software and user support problems.

6 april 1984

G.S. Stelling (Rijkswaterstaat, Rijswijk)
"A computational method for shallow water flow problems in civil engineering".

For hydraulic problems in civil engineering the usefulness of mathematical models based on the shallow water equations (SWE) is generally recognized.

Mathematical models based upon SWE are applied not only to estimate waterlevels but also for the calculation of detailed flow patterns. Especially if the flow pattern contains eddies the behaviour of a numerical method for the approximation of SWE is important. Not only should the numerical method be accurate but it must also be stable. The stability should not be obtained at the cost of numerical dissipation. For this type of problem many existing methods produce disappointing results, either instabilities are obtained or numerical dissipation causes very inaccurate results.

This contribution contains a concise description of the construction of a finite difference method for the approximation of SWE. Based on a detailed study of many important aspects a robust, yet accurate, finite difference method is constructed which is applicable to a wide range of practical problems of SWE in civil engineering. A number of examples of practical applications will illustrate this observation.

G.J.A. Loman (Hydronamic, Sliedrecht)
"Numerical modelling of two-dimensional free surface flow"

The design, planning and construction of projects, interfering the riverine or marine environment, as well as the managing of coast, estuaries, port and waterways, require a thorough knowledge of the free surface flow.

Before the recent development of sophisticated computer hardware and software started, engineers relied heavily on physical-scale models.

Nowadays, a number of more flexible and cost-effective numerical models for 2-dimensional depth-averaged flow have been developed. The partial differential equations describing the shallow water flow are derived by integrating the Navier-Stokes equations over the flow depth, using the Saint Venant hypotheses.

This paper highlights the experience of a consulting engineer using such a model, originally developed by Leendertse (1967).

The treatment of numerical snakes in this finite difference model as well as some computational results will be presented.

20 april 1984

P.M. van den Berg (Technische Hogeschool Delft, afd Elektrotechniek)
"Iterative computational techniques for solving integral equations"

In this paper we discuss some iterative techniques for solving integral equations, using an error criterion. We investigate the implications of the integrated square error criterion and the minimization of this error is taken as a condition for getting the best result. After discretization, the numerical implication of the least-square-error criterion leads to the numerical solution of a system of linear algebraic equations. Usually, this system is inverted by a direct method.

In the case, however, that we are dealing with large systems of equations, the problem of excessive computer time and computer storage required for direct numerical solution of systems of equations can be circumvented using a suitable iterative technique. Another argument to solve the pertinent systems of equations iteratively, is the evident fact that we should not solve the relevant systems of equations with a higher degree of accuracy than the one imposed by our error criterion.

In the present paper we discuss alternative implementations of some iterative techniques, in which the intermediate step of reduction of the problems to a system of linear algebraic equations is superfluous. The integrated square error is taken as a measure of the approximate solution from the exact one. Starting with an arbitrary initial guess and a set of arbitrarily chosen correction functions, a convergent iteration scheme is to be developed. Some suitably chosen choices for the correction functions are discussed. Some numerical results to a number of representative problems illustrate the rate of convergence of the different methods.

A.G. Tijhuis (Technische Hogeschool Delft, afd Elektrotechniek)
"Stability analysis of the marching-on-in-time method for one- and two-dimensional transient electromagnetic scattering problems"

The transient scattering of one- and two-dimensional electromagnetic fields by an obstacle of finite extent is investigated with the aid of the time-domain integral equation technique. In solving such equations with the marching-on-in-time method, numerical instabilities form a major problem. These instabilities can be attributed to the errors in the discretization of the source-type integrals that occur in the equations. In this paper, we formulate two so-called stability criteria for such a discretization which, if they are met, guarantee that the instability can be controlled by reducing the discretization step. With the aid of these criteria,

we analyze the solution of three electromagnetic scattering problems, namely the scattering of a pulsed plane wave by a one-dimensional, inhomogeneous, lossy dielectric slab and by a perfectly conducting or an inhomogeneous, lossy dielelectric cylinder. Numerical results are presented and discussed.

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J.J. Bisschop (Shell Research B.V., Amsterdam)
"On the importance of a modeling system for large-scale mathematical models"

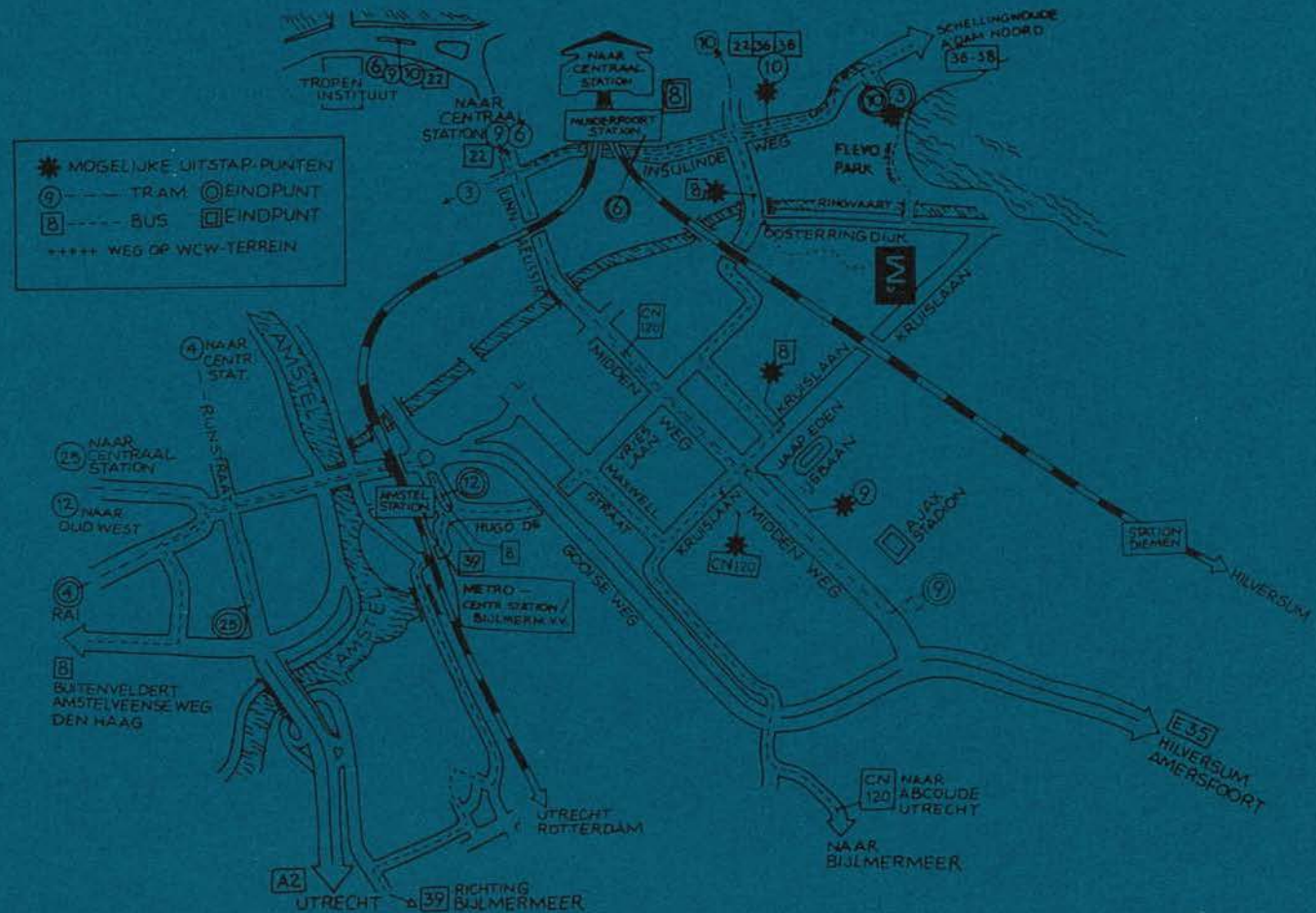
This paper is on the border line between numerical mathematics and the field of information technology. It will concentrate on the interface between a model builder on one side and a set of mathematical algorithms on the other. The information requirements for each side are different, and a translation step must be made for the preparation and solution of large-scale problems. In practice, this translation step is costly in terms of manpower and time. The General Algebraic Modeling Systems GAMS is an example of a system that automatizes this translation step for the class of mathematical programming problems. Such a system contains current and future benefits for both the model builder and the developer of mathematical software. Besides a general description of a modeling system, the paper will emphasize some of the current and future benefits for the developer of mathematical software. They center around the automatic interface with algorithms, the correction facilities in case of problems encountered during the solution phase, and the marketing of algorithmic software. Throughout the paper GAMS will be used as an illustration.

N. Praagman (Svasek B.V., Rotterdam)
"Finite element analysis of water-lubrication in oil-pipe lines"

The loss of energy, as a result of friction resistance of the wall, during the transport of oil through pipelines, has been the reason for investigations concerning the pumping of oil together with water. The idea is that water experiences less resistance of the wall than oil and will, due to (difference in) specific gravity and surface tension, cover the greatest part of the contact-area. Utilizing a numerical model, which is based on the finite element method and the Runge-Kutta-Fehlberg technique for the solution of ordinary differential equations it has been shown that indeed less energy is consumed

if oil together with water is transported. Besides an optimal oil-water ratio could be determined using the model. In the presentation attention will be paid to.

- the mathematical formulation of the problem
- the used numerical techniques
- results of computations
- practical impact on the water lubrication of oil.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