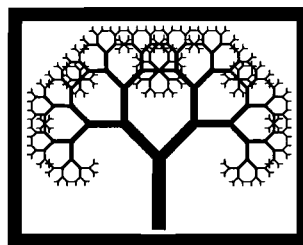


**COMPUTATIONAL
ENGINEERING
USING
METAPHORS FROM NATURE**

**COMPUTATIONAL
ENGINEERING
USING
METAPHORS FROM NATURE**

*Edited by
B.H.V. Topping*



CIVIL-COMP PRESS

CIVIL-COMP PRESS
10 Saxe-Coburg Place
Edinburgh, EH3 5BR, UK

CIVIL-COMP PRESS is an imprint of Civil-Comp Limited

© 2000, *Civil-Comp Limited*

British Library Cataloguing in Publication Data
A catalogue record for this book is available from the British Library

ISBN 0-948749-66-0

Printed in the Scottish Borders
by
MEIGLE PRINTERS LIMITED
Galashiels, Scotland

❖CONTENTS❖

1. NEURAL NETWORKS

- 1.1 NEURAL NETWORKS IN THE ANALYSIS OF ELASTOPLASTIC PLANE STRESS PROBLEM WITH UNILATERAL CONSTRAINTS, E. Pabisek and Z. Waszczyszyn, Institute of Computer Methods in Civil Engineering, Cracow University of Technology, Krakow, Poland 1
- 1.2 IDENTIFICATION FOR AXIAL FORCE AND BOUNDARY CONDITIONS OF AN ORTHOTROPIC RECTANGULAR PLATE USING NEURAL NETWORKS, I. Takahashi, Department of Mechanical Engineering, Kanagawa Institute of Technology, Kanagawa, Japan 7
- 1.3 PREDICTION OF MOMENT-ROTATION CHARACTERISTIC FOR SADDLE-LIKE CONNECTIONS USING FEM AND BP NEURAL NETWORKS, A. Kaveh†, D. Fazel-Dehkordi‡ and H. Servati†, †Department of Civil Engineering, Iran University of Science and Technology, Tehran, Iran, ‡Mazadran University of Science and Technology, Babol, Iran..... 15
- 1.4 USE OF NEURAL NETWORKS FOR DAMAGE DETECTION IN STRUCTURAL ELEMENTS USING WAVE PROPAGATION, L. Ziemianski and G. Piatkowski, Department of Structural Mechanics, Rzeszow University of Technology, Rzeszow, Poland 25
- 1.5 NEURAL NETWORKS IN UPDATING OF A TWELVE STOREY FRAME MODEL, B. Miller and L. Ziemianski, Department of Structural Mechanics, Rzeszow University of Technology, Rzeszow, Poland 31
- 1.6 NEURAL NETWORKS AND COLD-FORMED STEEL DESIGN, E.M.A. El-Kassas, R.I. Mackie and A.I. El-Sheikh, Department of Civil Engineering, University of Dundee, Dundee, U.K. 37
- 1.7 NEURAL NETWORK CONTROL OF STRUCTURES WITHOUT EMULATION OF DYNAMICS, D-H. Kim and I-W. Lee, Department of Civil Engineering, Korea Advanced Institute of Science and Technology, Taejon, Korea..... 45
- 1.8 MULTIPLE-SENSOR WEIGH-IN-MOTION OF ROAD VEHICLES USING A NEURAL NETWORK ALGORITHM, A. Shamseldin, B.J. Black and E. O'Brien, Department of Civil Engineering, University College, Dublin, Ireland..... 53
- 1.9 THE SCATTERED DATA INTERPOLATION PROCEDURE BASED ON A COUNTERPROPAGATION NEURAL NETWORK, S. Łukaszyk, Institute of Computer Methods in Civil Engineering, Cracow University of Technology, Cracow, Poland..... 59
- 1.10 NEURAL NETWORK PREDICTIVE TOOLS FOR SETTLEMENT RESPONSES DUE TO LONG-TERM DEWATERING ACTIVITIES, A.W. Sadek, F. El-Nahhas and A. El-Shenawy, Engineering Division, Kuwait Institute for Scientific Research, Safat, Kuwait 65
- 1.11 ERROR MINIMIZATION OF THE COUNTER-PROPAGATION NEURAL NET RESPONSE, A. Iranmanesh and N. Zeini, Department of Civil Engineering, University of Shaheed Ba-Honar, Kerman, Iran . 71

2. GENETIC ALGORITHMS

- 2.1 REAL VERSUS BINARY CODING IN GENETIC ALGORITHMS: A COMPARATIVE STUDY, P. Hajela† and C-Y. Lin‡, †Department of Mechanical Engineering, Aeronautical Engineering and Mechanics, Rensselaer Polytechnic Institute, Troy, NY, United States of America, ‡Department of Mechanical Engineering, National Taiwan University of Science and Technology, Taipei, Taiwan, Republic of China 77
- 2.2 DEVELOPMENT OF EFFICIENT INTEGRAL METHOD USING QUASI-RANDOM NUMBER AND GENETIC ALGORITHM, A.S. Matsuho† and D.M. Frangopol‡, †Department of Advanced Engineering, Anan National College of Technology, Anan-shi, Japan, ‡Department of Civil, Environmental and Architectural Engineering, University of Colorado, Boulder, Colorado, United States of America..... 85
- 2.3 A PRIMITIVE CROSSOVER FOR IMPROVING THE RELIABILITY OF GENETIC ALGORITHMS FOR STRUCTURAL OPTIMIZATION, M.H. Imam and M.A. Al-Shihri, Civil Engineering Department, Umm-Al-Qura University, Makkah, Saudi Arabia..... 91

2.4	APPLICATION OF CONCEPTION OF DISTANCE FOR THE GENETIC ALGORITHM, H. Liang and J.Z. Cui, Institute of Computational Mathematics and Science/Engineering Computing, Chinese Academy of Science, Beijing, P.R. China	99
2.5	GENE THERAPY FOR IMPROVING THE PERFORMANCE OF GENETIC ALGORITHM IN PIPE NETWORK OPTIMIZATION, A. Al-Khomairi and M.H. Imam, Civil Engineering Department, Umm Al-Qura University, Makkah, Saudi Arabia	105
2.6	A GENETIC ALGORITHM BASED OPTIMUM BRACING DESIGN OF NON-SWAY TALL STEEL FRAMES, E.S. Kameshki and M.P. Saka, Department of Civil and Architectural Engineering, University of Bahrain, Isa Town, State of Bahrain	111
2.7	AN APPLICATION OF A REAL NUMBER MICRO-GENETIC ALGORITHM TO THE SHAPE OPTIMISATION OF IN-PLANE STRESSED PLATE ELEMENTS, B. Ceranic and C. Fryer, School of Engineering, University of Derby, Derby, United Kingdom	121
2.8	A HYBRID GRAPH-GENETIC METHOD FOR DOMAIN DECOMPOSITION, A. Kaveh† and H.A. Rahimi Bondarabady‡, †Department of Civil Engineering, Iran University of Science and Technology.Tehran, Iran, ‡Tarbiat Modarres University, Tehran, Iran	127
2.9	LIMIT ANALYSIS OF MASONRY WALL WITH OPENINGS BY GENETIC ALGORITHM, Y. Kohama†, T. Takada†, A. De Stefano‡, A. Miyamura* and T. Aoki*, †Department of Architecture, Mie University, Tsu, Japan, ‡Department of Structural and Geotechnical Engineering, Politecnico di Torino, Torino, Italy, *SDA, Nagoya City University, Nagoya, Japan	135
2.10	A PLATFORM INDEPENDENT ENGINEERING OPTIMISATION TOOL BASED ON GENETIC ALGORITHMS AND DISTRIBUTED COMPUTING APPLIED TO GAS TURBINE COMBUSTOR PRELIMINARY DESIGN, J.M. Rogero and P.A. Rubini, School of Mechanical Engineering, Cranfield University, Cranfield, United Kingdom.....	143
2.11	OPTIMAL DESIGN OF TWENTY-FIVE BAR TRUSS LAYOUT USING A GENETIC ALGORITHM, I.A. Azid†, K.N. Seetharamu† and A.S.K. Kwan‡, †School of Mechanical Engineering, University Sains Malaysia, Tronoh, Malaysia, ‡Cardiff School of Engineering, Cardiff, United Kingdom.....	151
2.12	OPTIMUM DESIGN OF TRUSSES USING A GENETIC ALGORITHM, Y. Ayvaz and Z. Aydin, Department of Civil Engineering, Karadeniz Technical University, Trabzon, Turkey.....	159
3.	SIMULATED ANNEALING	
3.1	IMPROVEMENTS OF SIMULATED ANNEALING IN OPTIMAL STRUCTURAL DESIGNS, T-Y. Chen and J-J. Su, Department of Mechanical Engineering, National Chung-Hsing University, Taichung, Taiwan..	169
3.2	LAYOUT OPTIMIZATION OF TRUSSES USING SIMULATED ANNEALING, O. Hasancebi and F. Erbatur, Department of Civil Engineering, Middle East Technical University, Ankara, Turkey	175
4.	CELLULAR AUTOMATA	
4.1	STRUCTURE OPTIMIZATION SCHEME BASED ON CONCEPT OF CELLULAR AUTOMATA, E. Kita and T. Toyoda, School of Informatics and Sciences, Nagoya University, Nagoya, Japan.....	191
4.2	PARALLELISM MANAGEMENT IN CELLULAR AUTOMATA NETWORKS, C.R. Calidonna, C. Di Napoli and M. Mango Furnari, Istituto di Cibernetica, Consiglio Nazionale delle Ricerche, Arco Felice NA, Italy	199

❖ PREFACE ❖

This volume contains a selection of contributed papers presented at *The Fifth International Conference on Computational Structures Technology* and *The Second International Conference on Engineering Computational Technology*, held in Leuven, Belgium from 6-8 September 2000. The papers in this volume include the following topics: Neural Networks; Genetic Algorithms; Simulated Annealing; and Cellular Automata. The complete list of conference proceedings volumes are as follows:

- Identification, Control and Optimisation of Engineering Structures
G. De Roeck and B.H.V. Topping (Editors)
Civil-Comp Press, 2000, ISBN 0-948749-74-1
- Computational Civil and Structural Engineering
G. De Roeck and B.H.V. Topping (Editors)
Civil-Comp Press, 2000, ISBN 0-948749-73-3
- Computational Steel Structures Technology
M. Iványi, J.P. Muzeau and B.H.V. Topping (Editors)
Civil-Comp Press, 2000, ISBN 0-948749-72-5
- Computational Concrete Structures Technology
Z. Bittnar and B.H.V. Topping (Editors)
Civil-Comp Press, 2000, ISBN 0-948749-71-7
- Developments in Engineering Computational Technology
B.H.V. Topping (Editor)
Civil-Comp Press, 2000, ISBN 0-948749-70-9
- Computational Techniques for Materials, Composites and Composite Structures
B.H.V. Topping (Editor)
Civil-Comp Press, 2000, ISBN 0-948749-69-5
- Computational Mechanics: Techniques and Developments
B.H.V. Topping (Editor)
Civil-Comp Press, 2000, ISBN 0-948749-68-7
- Finite Elements: Techniques and Developments
B.H.V. Topping (Editor)
Civil-Comp Press, 2000, ISBN 0-948749-67-9
- Computational Engineering using Metaphors from Nature
B.H.V. Topping (Editor)
Civil-Comp Press, 2000, ISBN 0-948749-66-0
- Computational Mechanics for the Twenty-First Century
B.H.V. Topping (Editor)
Saxe-Coburg Publications, 2000, ISBN 1-874672-13-X

I should like to thank all the authors for their contributions and in particular those who presented their papers in Leuven. I must also thank the members of the Conference Editorial Boards who helped in many ways before and during the conference.

The members of the Editorial Board for Computational Structures Technology Conference 2000, were: Prof. H. Adeli, USA; Prof. S. Ahmad, Bangladesh; Prof. Dr. N. Akkas, Turkey; Prof. J.E. Akin, USA; Prof. E. Alarcon, Spain; Prof. G. Alduncin, Mexico; Prof. E. Anderheggen, Switzerland; Prof. F. Armero, USA; Dr. H. Askes, The Netherlands; Prof. M.H. Baluch, Saudi Arabia; Prof. N. Banichuk, Russia; Prof. C.C. Baniotopoulos, Greece; Prof. H.J.C. Barbosa, Brazil; Prof. K.J. Bathe, USA; Prof. J.L. Batoz, France; Prof. J. Baugh, USA; Dr A.A. Becker, England; Prof. T. Belytschko, USA; Prof. M. Bernadou, France; Prof. N. Bicanic, Scotland; Prof. Z. Bittnar, Poland; Prof. K-U. Bletzinger, Germany; Prof. P. Boisse, France; Prof. R.I. Borja, USA; Prof. M. Bradford, Australia; Prof. F. Brezzi, Italy; Prof. D. Briassoulis, Greece; Prof. M.L. Bucalem, Brazil; Prof. T. Bulenda, Germany; Dr. J.W. Bull, England; Prof. O.S. Bursi, Italy; Prof. G.F. Carey, USA; Prof. H.C. Chan, Hong Kong; Dr D. Chapelle, France; Prof. W.F. Chen, USA; Prof. G. Cheng, China; Prof. J. Chenot, France; Dr. G. Chiandussi, Italy; Prof. C-K. Choi, Korea; Prof. K. K. Choi, USA; Dr. C. Cingini, Italy; Prof. J.Y. Cognard, France; Prof. R. de Borst, The Netherlands; Prof. G. de Roeck, Belgium; Dr. M.A. de Rosa, Italy; Prof. G. Degrande, Belgium; Dr R. Delpak, Wales; Prof. C.S. Desai, USA; Dr. M. Dhanasekar, Australia; Prof. M. Doblare, Spain; Prof. I. Doltsinis, Germany; Prof. L. Dunai, Hungary; Dr. E.N. Dvorkin, Argentina; Dr. N.F.F. Ebecken, Brazil; Prof. I. Elishakoff, USA; Prof. F. Erbatur, Turkey; Prof. A. Eriksson, Sweden; Prof. H.A. Eschenauer, Germany; Prof. M. Farshad, Switzerland; Prof. C.A. Felippa, USA; Prof. T.E. Fenske, USA; Dr A.J. Ferrante, Italy; Prof. D. Frangopol, USA; Prof. M.B. Fuchs, Israel; Prof. R.E. Fulton, USA; Prof. P. Gaudenzi, Italy; Prof. N. Gebbeken, Germany; Prof. U.A. Girhammar, Sweden; Prof. J-C. Gelin, France; Prof. P.L. Gould, USA; Prof. R.V. Grandhi, USA; Prof. D. Grierson, Canada; Prof. R. Haftka, USA; Prof. P. Hajela, USA;

Prof. P. Hamelin, France; Prof. D. Hartmann, Germany; Prof. G.R. Heppler, Canada; Prof. J. Herskovits, Brazil; Prof. M. Hoit, USA; Prof. T.J.R. Hughes, USA; Prof. M. Ibrahimbegovic, France; Prof. H. Irschik, Austria; Prof. M. Iványi, Hungary; Prof. K. Jarmai, Hungary; Prof. M. Kamiya, Japan; Prof. T. Kant, India; Prof. B. Karihaloo, Wales; Prof. S. Kato, Japan; Prof. J.T. Katsikadelis, Greece; Prof. A. Kaveh, Iran; Prof. M. Kawaguchi, Japan; Dr A. Khan, Australia; Prof. U. Kirsch, Israel; Dr. M. Kleiber, Poland; Prof. M.D. Kotsovos, Greece; Prof. V. Koumoussis, Greece; Prof. A. Kounadis, Greece; Prof. W.B. Kräzig, Germany; Prof. B.H. Kroplin, Germany; Prof. P. Ladèveze, France; Prof. K.L. Lawrence, USA; Prof. S.H. Lee, USA; Prof. Le Tallec, France; Prof. A.Y.T. Leung, England; Prof. R. Levy, Israel; Prof. A. Liolios, Greece; Prof. P.B. Lourenço, Portugal; Prof. I. MacLeod, Scotland; Dr J. Mackerle, Sweden; Prof. G. Manfredi, Italy; Prof. H.A. Mang, Austria; Prof. D. Manolis, Greece; Prof. J.B. Martin, South Africa; Prof. H.G. Matthies, Germany; Dr E.A.W. Maunder, England; Prof. I.M. May, Scotland; Prof. F. Mazzolani, Italy; Prof. J.L. Meek, Australia; Prof. U.F. Meissner, Germany; Prof. C. Meyer, Germany; Prof. M. Mikkola, Finland; Dr. S. Modak, USA; Dr. K. Morgan, Wales; Prof. C.A. Mota Soares, Portugal; Prof. Z. Mroz, Poland; Dr. A. Muc, Poland; Prof. J.-P. Muzeau, France; Prof. A. Needleman, USA; Prof. G.P. Nikishkov, Japan; Prof. A.K. Noor, USA; Prof. H. Nooshin, England; Prof. R. Ohayon, France; Prof. N. Olhoff, Denmark; Prof. J. Oliver, Spain; Prof. E. Onate, Spain; Prof. E. Papa, Italy; Prof. M. Papadarakis, Greece; Prof. P. Papalambros, USA; Prof. D. Parsons, USA; Prof. P. Pedersen, Denmark; Dr D. Peric, Wales; Prof. J. Petrolito, Australia; Prof. C.P. Providakis, Greece; Dr. E. Providas, Greece; Prof. J. Rakowski, Poland; Prof. C.V. Ramakrishnan, India; Prof. E. Ramm, Germany; Prof. F.G. Rammerstorfer, Austria; Prof. B.D. Reddy, South Africa; Prof. E. Riks, The Netherlands; Prof. H. Rothert, Germany; Dr. E. Salajegheh, Iran; Prof. A. Samartin, Spain; Prof. A. Samuelsson, Sweden; Prof. J.L.T. Santos, Portugal; Prof. E. Schnack, Germany; Dr B.A. Schrefler, Italy; Prof. G.I. Schueller, Austria; Prof. K. Schweizerhof, Germany; Dr A. Selby, England; Prof. G.J. Simitzes, USA; Prof. S. Sloan, Australia; Prof. P. Spanos, USA; Dr E. Spreeuw, The Netherlands; Prof. G. Steven, Australia; Prof. H. Sugimoto, Japan; Prof. K.S. Surana, USA; Prof. C.C. Swan, USA; Prof. C.A. Syrmakizis, Greece; Prof. B.A. Szabo, USA; Dr K.Y. Sze, Hong Kong; Prof. I. Takewaki, Japan; Prof. T. Tarnai, Hungary; Prof. J.W. Tedesco, USA; Prof. A.B. Templeman, England; Prof. G. Thierauf, Germany; Prof. R. Tinawi, Canada; Dr. V.V. Toropov, England; Prof. M. Touratier, France; Prof. P. Trompette, France; Prof. G. Tsamasphyros, Greece; Dr G. Turvey, England; Prof. F. van Keulen, The Netherlands; Prof. J. Vantomme, Belgium; Prof. I. Vardoulakis, Greece; Prof. F. Venancio-Filho, Brazil; Dr. P. Venini, Italy; Prof. K.S. Viridi, England; Prof. W. Wagner, Germany; Prof. X. Wang, USA; Prof. Z. Waszczyszyn, Poland; Prof. N.P. Weatherill, Wales; Prof. R. Weixin, Singapore; Prof. D.W. White, USA; Prof. N.E. Wiberg, Sweden; Prof. E.L. Wilson, USA; Prof. M. Witkowski, Poland; Prof. U. Wittek, Germany; Dr J.P. Wolf, Switzerland; Dr J. Wood, Scotland; Dr R.D. Wood, Wales; Prof. P. Wriggers, Germany; Dr. G. Yagawa, Japan; Prof. Y-B. Yang, Taiwan and Dr T. Zimmermann, Switzerland.

The members of the Editorial Board for Engineering Computational Technology Conference 2000, were: Prof. R. Abascal, Spain; Dr R. Adey, England; Prof. M.H. Aliabadi, England; Dr. C.J. Anumba, England; Prof. C.G. Armstrong, Northern Ireland; Prof. Z.P. Bazant, USA; Prof. A.I. Beltzer, Israel; Prof. G.F. Carey, USA; Dr. B. Codenotti, Italy; Prof. L. Damkilde, Denmark; Prof. F. Darve, France; Dr M. Dayde, France; Dr C. Di Napoli, Italy; Prof. E. Dick, Belgium; Prof. I.S. Duff, England; Dr A. Duller, Wales; Prof. D.J. Evans, England; Prof. A. Faghri, USA; Dr J. Fingberg, Germany; Prof. U. Gabbert, Germany; Prof. R.R. Gajewski, Poland; Prof. L. Gaul, Germany; Dr P.L. George, France; Prof. D. Givoli, Israel; Prof. B. Gustafsson, Sweden; Dr S. Hernandez, Spain; Dr. S. Idelsohn, Argentina; Prof. M.H. Imam, Saudi Arabia; Prof. A.R. Ingraffea, USA; Prof. K. Ishii, Japan; Dr M. Isreb, Australia; Prof. Y. Jaluria, USA; Prof. J. Jeronimidis, England; Dr P.K. Jimack, England; Dr M. Kara, England; Prof. T.G. Keith Jr., USA; Prof. V.M. Kovenya, Russia; Dr B. Kumar, Scotland; Prof. Y.S. Kim, USA; Dr D. Kiritsis, Switzerland; Dr. L. Lämmér, Germany; Prof. P. Leger, Canada; Dr G. Lonsdale, Germany; Prof. T. Lookman, Canada; Prof. J.J. McGuirk, England; Dr J.J. McKeown, Northern Ireland; Dr. R.I. Mackie, Scotland; Prof. M. Malafaya-Baptista, Portugal; Prof. N.C. Markatos, Greece; Prof. K. Matsuno, Japan; Prof. G. Meier, Italy; Prof. A. Meyer, Germany; Dr. J. Miles, Wales; Prof. G. Molnarka, Hungary; Prof. C.M. Mota Soares, Portugal; Prof. Z. Mroz, Poland; Dr M. Napolitano, Italy; Prof. D.T. Nguyen, USA; Prof. A.K. Noor, USA; Prof. P.H. Oosthuizen, Canada; Prof. K. Orsborn, USA; Prof. M.P. Païdoussis, Canada; Dr P.C. Pandey, India; Dr I.C. Parmee, England; Dr R. Pozo, USA; Dr A. Preumont, Belgium; Prof. H-W. Reinhardt, Germany; Prof. Z. Ren, Slovenia; Dr L.M. da S. Ribeiro, Portugal; Prof. J. R. Rice, USA; Dr D. Robinson, Northern Ireland; Prof. D. Roose, Belgium; Prof. F-X Roux, France; Dr M.G. Sainsbury, Hong Kong; Prof. H. Schaeffer, USA; Prof. K.N. Seetharamu, Malaysia; Prof. R.P. Shaw, USA; Prof. M.S. Shephard, USA; Dr J. Sienz, Wales; Dr H.D. Simon, USA; Prof. K. Sobczyk, Poland; Dr J. Sobieski, USA; Prof. B. Spalding, England; Prof. G.E. Stavroulakis, Germany; Prof. B. Sunden, Sweden; Prof. K.K. Tamma, USA; Dr T.D. Taylor, USA; Dr A.S. Usmani, Scotland; Prof. W.S. Venturini, Brazil; Prof. V.R. Voller, USA; Dr C. Walshaw, England; Dr M. Wolfshtein, Israel; Dr P K Woodward, Scotland and Prof. L.C. Wrobel, England.

These Conferences could not have been organised without the contribution of many people who helped in their planning, organisation and execution. Professor G. De Roeck was a valuable source of help locally in Leuven and in many aspects of the organisation of the conferences. Professor K.J. Bathe and Professor A.K. Noor were a constant source of encouragement and their continued support of this conference series is gratefully acknowledged. Professor Z. Bittnar, Professor M. Iványi, Professor J.P. Muzeau and Professor G. De Roeck contributed to the success of the

meeting by helping with the organisation and editorial of the volumes as listed above.

My thanks are also due to all at Civil-Comp Press for their help and perseverance in the realisation of these conferences, particularly Mrs Rosemary Brodie. The assistance of members of the Structural Engineering Computational Technology Research Group at Heriot-Watt University, Edinburgh is gratefully acknowledged especially from Roman Putanowicz, Janos Nezö and Péter Iványi. The delights of Leuven were first drawn to my attention by Jelle Muylle, a former student of Professor G. De Roeck. Jelle's tireless and enthusiastic assistance in bringing these Conferences to fruition is gratefully acknowledged.

Barry H.V. Topping
Department of Mechanical and Chemical Engineering
Heriot-Watt University, Edinburgh
August 2000