Applications of Evolutionary Algorithms

collected by

Thomas Bäck
Frank Hoffmeister
Hans-Paul Schwefel

5. Extended Edition

Abstract

This list presents references to applications of Evolutionary Algorithms (EAs), i.e. Evolution Strategies (ESs), Genetic Algorithms (GAs), Evolutionary Programming (EP) and mixed forms to several real-world problems or at least problems which have potential industrial applications. Each entry explains very briefly an application. The division into topics is rather preliminary. Whenever a company or institution is known which has presented the results, this is also mentioned in the list.

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Preface

Evolution Strategies (ESs), *Genetic Algorithms* (GAs), and *Evolutionary Programming* (EP) are powerful direct search optimization methods which are gleaned from organic evolution. During the sixties and seventies these algorithms emerged independently from each other in the United States (GAs, EP) and Germany (ESs). Nevertheless, all of them share the same working principles from orgranic evolution. Hence, they are summarized under the term *Evolutionary Algorithms* (EAs).

The presented list tries to provide an overview of existing applications to real-world problems and scientific toy-problems which are supposed to be relevant for the solution of real-world problems in the future.

The list was collected by reviewing available publications refering to an Evolution Algorithm. For each application found an entry is provided describing very briefly the kind of application. Whenever a company or an institution is known it is also mentioned in the entry.

The whole list separates into two parts. First, the list of applications is given. Its structuring of application domains is rather preliminary and may change in future editions. Each entry is marked by a citation key which may be used to look up the corresponding bibliographic data in the second part of the list.

The type of algorithm used in a particular application can be derived from the type of brackets around the citation key:

[...]	reference to Evolution Strategies (ESs)
(...)	reference to Genetic Algorithms (GAs)
{...}	reference to Evolutionary Programming (EP)
<...>	general reference to Evolutionary Algorithms (EAs)

Within each section applications are grouped according to the algorithm used. In order to facilitate easy recognition these groups are also marked by a separating line. Within each group entries are sorted with respect to the year of publication and the authors' initials.

The number of papers dealing with GA-applications has increased considerably since 1991. As a consequence, only selected GA-applications dated from 1993 and later are included in the list.

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[Pap73a] Simulation of protein evolution.
Institute of Biology, Universität Tübingen

[Pap73b] Simulated evolution of behaviour patterns in paraonis fulgens.
Institute of Biology, Universität Tübingen

[Kot79] Scenarios for explaining the intangible variance in genetically identical populations.
Veterinarian University of Hannover

[Rec82] Simulating the evolution of optical lenses.
Scenarios for explaining the intangible variance in monoclonal individuals.
Department of Bionics and Evolution Technique, TU Berlin

[BB83] Parameter optimization for a simulation model of genetic signal transmissions based on RNA-transcription.

[Ber84] Parameter identification for a model of synthesis processes inside fermentors.
Fachbereich Lebensmitteltechnologie und Biotechnologie, TU Berlin

[KMW84] Parameter optimization for complex models of ecosystems.
Central Institute of Cybernetics and Information Processes, Academy of Sciences, Berlin

[RK84] Optimization of fermentation processes.
Central Institute of Microbiology and Experimental Therapy, Jena

[PK85] Simulated evolution of mating behaviour of a dragon fly.
Chair of Ecology, RWTH Aachen

(sFWBW92) Individual medium composition for each strain of a bio-reactor.

2 Chemistry and Chemical Engineering

[MB73] Optimization of a two-component nozzle for the material balance in chemical processes.
Institut für Chemieingenieurtechnik, TU Berlin

[Rie81] Design and parameterization of technical catalyzers.
Institut für Chemische Verfahrenstechnik, Universität Karlsruhe

[Her83] Regression analysis of arbitrary functions.
Approximate description of the pressure distribution during an explosion.
Determination of the ratio of nitroglycerine to nitroglycol for explosives by approximating empirical IR-extinction data.
Classification of the tendency for firedamps of a powder bag composition.
Dynamit Nobel AG und WASAG-Chemie Sythen GmbH

[Rie84] Optimal composition of electrolytes for galvanization with tin.
Optimal chrome plating solutions to zinc-plate surfaces.
Fachbereich Verfahrenstechnik, TU Berlin

[HK86] Minimization of the energy in clusters of Ar_3^+ molecules.
Hahn-Meitner-Institut, Berlin

[BPBG87] Parameter estimation of dynamic models for the kinetic analysis of absorption spectrums.
Gesellschaft für Strahlen- und Umweltforschung mbH, München

[FW87] Determination of pulse successions for magnetic resonance experiments.
Physical Chemistry Laboratory, Oxford University

[Kir87] Alignment of theoretical spectrums with measured EPR-sprectrums.
Institut für Organische Chemie, Freie Universität Berlin

[KV88] Determination of clusters of noble gas ions with minimal energy.
Hahn-Meitner-Institut GmbH, Berlin

[Mic89] Optimal design of flow channels, optimal control, and alignment of casting machinery for processing of plastics.
Institute for Plastics Processing, Aachen

[MMH89]
[Mic90] Determination of optimal working points for the processing of plastics.
Institute for Plastics Processing, Aachen

[Wu89] Identification of bands in NMR-spectrums.
Department of Chemistry, Cambridge University

[Got90] Optimal design of magnets for NMR analyses.
Institute of Scientific Instruments, Czechoslovak Academy of Sciences Královopolská

[MH90] Pre-optimization of kinetic parameters of a reaction model for the heterogeneous-catalytic dehydrochlorination of 1,1-difluorine-1-chlorine-ethane.

[WB90] Identification of the competition coefficients for a simplified competition equilibrium adsorption model (SCAM).
Sanitary Engineering and Water Management Department, TU Delft

[Fre92] Pulse design for selective excitation in high resolution NMR.
Department of Chemistry, Cambridge University

[FDK92] Determination of the structure of globally energy-minimal Ne_n^+–clusters ($n \leq 22$).

[GPM+92] Minimization of inhomogeneity in magnetic field devices used for NMR and MRI by means of a FEM of the magnetic poles and the resulting field.
Department of Electrical Engineering, University of Pavia, Italy

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[Kir92] Least-square fitting of high-resolution electron paramagnetic resonance (EPR) spectra.

[RM92] Determination of the equilibrium state in chemically reactive systems consisting of upto 25 solid, liquid, and gaseous components.
Chair of Technical Thermodynamics, RWTH Aachen

(LBBK91) Conformational analysis of DNA by NOE-spectra (Nuclear Overhauser Enhancement). Minimisation of the difference between experimental spectra and conformations (molecular structures) generated by a GA.

(LK89) Conformational analysis of DNA by NMR-spectra.

(LK91) Optimal selection of wavelengths in multi-component photometric analysis.

(LWvA+91) Conformational analysis of DNA.

{Fog93a} Determination of conformation parameters of organic molecules with minimal energy demonstrated for C_2H_6.
ORINCON Corporation, San Diego, CA

3 Computer Aided Design

[Lic65] Shape optimization of a 90° pipe knee with minimal drag.
Institut für Strömungstechnik, TU Berlin

[Rec65] Minimized drag of a wrist plate.
Fachgebiet Bionik und Evolutionstechnik, TU Berlin

[Sch68] Optimal structural design of a two-phase nozzle with maximum impulse performance.
AEG Forschungsinstitut, Berlin

[Heu70] Core optimization of sodium cooled fast-breeder reactors w.r.t. the cost of fuel and return on capital.
Kernforschungsanlage Karlsruhe

[Noo70] Determination of design parameters of a pneumatic shock absorber.
Zentrallaboratorium für Datentechnik, Siemens AG

[Unv70] Volume optimization of girder constructions in view of instabilities.
Institut für Luft- und Raumfahrttechnik, TU Berlin

[HLW71] Volume optimization of girder bridges in view of instabilities.
Institut für Luft- und Raumfahrt, TU Berlin

[Noo71a] Design and parameterization of a 4-joint drive unit.
Zentrallaboratorium für Datentechnik, Siemens AG

[Gas73] Determination of shape and parameterization of parts of apparatus.
Institut für Meß- und Regelungstechnik, TU Berlin

[HLW73] Weight-optimal positioning of joins for half-timbered constructions.
Institut für Luft- und Raumfahrt, TU Berlin

[K+73] Optimized geometry of perpendicularly attacked cooling vanes.

[Rec73] Shape optimization of perpendicularly attacked cooling vanes.
Fachgebiet Bionik und Evolutionstechnik, TU Berlin

[Har74] Minimization of the maximum circular momentum of beam-type cylindric shell constructions.
Fachbereich Bauwesen, Universität Dortmund

[Ley74] Weight optimization of girder constructions.
Fachbereich Verkehrswesen, TU Berlin

[Rin74] Optimal transformer circuits for antenna matching units.
Fachbereich Elektrotechnik, Hochschule der Bundeswehr, München

[Höf76] Shape optimization of lightweight half-timbered constructions.
Institut für Luft- und Raumfahrt, TU Berlin

[And77] Synthesis of a 4-joint drive unit.

[Har77] Design of flat hyperbolic paraboloid shell constructions with minimal costs.
Fachbereich Bauwesen, Universität Dortmund

[Höf77] Optimal shape of lightweight half-timbered constructions with fixed structure.
Institut für Luft- und Raumfahrt, TU Berlin

[Kan77] Design of ball-bearings with maximum load capacity.
Lehrstuhl für Maschinenelemente und Konstruktionslehre, Ruhr-Universität Bochum

[WHB77] Shape optimization of girder constructions with given topology.
Institut für Luft- und Raumfahrt, TU Berlin

[Har78] Weight optimization of a single-field girder construction.
Fachbereich Bauwesen, Universität Dortmund

[Hil78] Optimal design of dynamically loaded girders.
Institute of Mechanics, Ruhr-Universität Bochum

[Mar78] Optimization of the energy efficiency of a thermal water jet propulsion.
Institut für Luft- und Raumfahrt, TU Berlin

[Kan79] Optimization method within the `ASDO` program package for parameter optimization of computer-aided designs.
Lehrstuhl für Maschinenelemente und Konstruktionslehre, Ruhr-Universität Bochum

[BRW80] Design of a centrifugal compressor with optimal stage power.
Klein, Schanzlin und Becker AG, Saarbrücken

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[Law81]
[LT83] Optimized resistance to earthquakes of steel structure buildings based on finite-element-modelling.
Gesamthochschule/Universität Essen

[Fei82] Optimization of a freely rested girder construction with central load.
Institut für Mathematik, Johannes Keppler Universität, Linz

[Fun82] Weight optimization of welded cabinets.
Tension optimization of idealized flat structures: cantilever beam, boltings, crosshead.
Institut für Konstruktions- und Fertigungstechnik, Hochschule der Bundeswehr, Hamburg

[Nac82] Weight optimization of girder constructions.
Drag optimization of a wrist plate.
Akademie der Wissenschaften und der Literatur, Mainz

[Nei82] Noise reduction of radial fans.
Institut für Experimentelle Strömungsmechanik, Deutsche Forschungs- und Versuchanstalt für Luft- und Raumfahrt e.V.

[ORZ82] Parameterization of a car suspension w.r.t. optimal comfort (K-value) according to VDI guide line 2057.
Identification of unmeasurable vehicle parameters for a 1-track simulation model.
Optimal deformation characteristics for collisions of vehicles of different masses.

[Pin82]
[Pin83a]
[Pin83b] Minimized drag of a body of revolution.
College of Technology, University of Houston, Texas

[Rup82] Synthesis of controllers for hydraulic setting mechanisms.
Fachbereich Maschinenbau, Universität-Gesamthochschule Duisburg

[Wil82] Design of boltings with minimal weight.
Institut für Konstruktions- und Fertigungstechnik, Hochschule der Bundeswehr, Hamburg

[Zet82] Synthesis of an active suspension with optimal RMS-values.
Fachbereich Maschinentechnik, Universität-Gesamthochschule Paderborn

[Har84] Parameter adaptation of finite element models for structure optimization.
Department of Civil Engineering, University of California, Berkeley

[WSR84] General purpose optimization method in a sequential multi-criteria optimization system.
Central Institute of Cybernetcis and Information Processes, Academy of Sciences, Berlin

[Har85] General purpose optimization method in a CAD-system.
Fachbereich Bauwesen, Universität Dortmund

[Ler85] Optimization of the efficiency, sensivity and bandwidth of ultrasonic converters for medical diagnoses.
Siemens AG, Forschungslaboratorium Erlangen

[Win85]
[Win86] Optimized throughput and homogeneity of the dose rate of Gamma-radiation equipment for food preservation.
Zentralinstitut für Isotopen- und Strahlenforschung, Leipzig

[DM86] Diagonalization of a stiffness matrix for the decoupling of imposed oscillations of the elastically mounted Porsche aeroplane engine PFM 3200.
Porsche AG, Stuttgart

[Kob87] Optimization of spiral springs and damping of vibrations of an engine suspension.

Institute of Computer-Applications, Universität Stuttgart

[HSS88] Data analysis of experimental data for the verification of burning off programs controlling nuclear reactors of type `WWER-440`.
VEB Kernkraftwerke "Bruno Leuschner", Greifswald, DDR

[RBK88] General purpose optimization method within the program package `CARAT` (Computer Aided Reserach Analysis Tool) for structure optimization.
Sonderforschungsbereich 230, Universität Stuttgart

[WN88] Optimization of parametric descriptions of systems of optical lenses.
VEB Kombinat Carl Zeiss, Jena

[Egg90] Minimized weight and deflection of girder constructions.
Fachbereich Verfahrenstechnik, TU Berlin

[PZ90]
[PVZ+90] Optimization of electromagnetic flux at the ends of a dipole magnet based on a finite element model.
Institute for Fundamentals and Theory in Electrical Engineering, Graz

[Jen91] Optimum design of trussed-beam roof structures.
Department of Civil Engineering, University of Leeds, UK

(Suc91) Optimal design and performance of finite impulse response (FIR) digital filters.
Department of Computing, Polytechnic Torquay, United Kingdom

4 Physics and Data Analysis

[PW73] Parameter estimation of arbitrary regression functions to describe numerical time series data.

[Rod76] Determining configurations of dislocation groups in neutron-radiated Cu monocristals.
Naturwissenschaftliche Fakultät, TU Braunschweig

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[RN76] Determining the optimal configuration of defects in cristalline materials.
Institut A für Physik, TU Braunschweig

[JGD78] Parameter estimation of an ansatz for solving the Thomas-Fermi equation of a 3-atom system.
Institut für Theoretische Physik, Universität Frankfurt

[DGT79] Parameter estimation of the Thomas-Fermi-Derac-von Weizäcker equation of n-atom systems.
Institut für Theoretische Physik, Universität Frankfurt/Main

[GD79] Parameter estimation of an ansatz to solve Thomas-Fermi and Thomas-Fermi-Derac-Weizsäcker equations.
Institut für Theoretische Physik, Universität Frankfurt/Main

[Nor80a] Parameter estimation of fluid-dynamic problems.
Laboratoire d'Hydraulique, Ecole Polytechnique Federale, Suisse

[Nor80b] Parameter identification of a time-dependent stochastic model of floods.
Laboratoire d'Hydraulique, Ecole Polytechnique Federale, Suisse

[Pöp81] Solving the Brachistochronen problem with constraints.
Institut für Strömungslehre und Strömungsmaschinen, Hochschule der Bundeswehr, Hamburg

[Sch81b] Optimization of microwave circuits.
Fachgebiet Hochfrequenztechnik, Universität Bremen

[SGD82] Parameter estimation for solving the TFDW equation of neutral atoms.
Institut für Theoretische Physik, Universität Frankfurt/Main

[SD86] Parameter identification of a TFDW model to determine the density of atoms.
Institut für Theoretische Physik, Goethe Universität Frankfurt am Main

[THS88] Checking a model of dislocations in Er-doped GaAs.
Physikalisches Institut, Universität Stuttgart

[Ban89] Identification of local optima in spin-glas like neural networks for pattern classification and for associative memory purposes.
Institut für Theoretische Physik und Synergetic, Universität Stuttgart

[Bey90] Determination of stable steady states in dissipative systems.
WB Physik, Hochschule für Architektur und Bauwesen, Weimar, DDR

[GWH90] Minimization of two-dimensional spin glass Hamiltonians.
Minimization of the autocorrelation of binary sequences.

[KW90] Determining the ideal control of longitudinal waves in a rod with Voigt damping.
Department of Mechanical Engineering, MIT, USA

[Bey92] Arrangement of cavities in a linear accelerator (LINAC) for minimal beam-break-up.

(Hem92a)	Adaptation of strategy parameters to reconstruct physical processes of the LEP collider at CERN.
[Kas92]	Shape optimization of electrical conductors w.r.t. minimal power losses based on FE-modelling.
(Ban90)	Finding the groundstate of an SK-spinglas.
(JH91)	Construction of mathematical models of dynamical systems by parameter fitting of models.
(HBH92)	Optimization of Monte Carlo generator parameters by fitting distributions of global event shape variables and single particle distributions from generated events to measured data.
(Hem92a) (Hem92b)	Reconstruction of physical processes after the annihilation of particles in collider rings.
{Fog91}	Application of Evolutionary Programming to system identification and parameter estimation.
{Fog92}	Application of Evolutionary Programming to an acoustic modeling example of ice cracks. *ORINCON Corporation, San Diego, CA*
{FS93}	Evolving a mix of fuzzy sets to cluster multi-dimensional data based on fuzzy hyperboxes. *ORINCON Corporation, San Diego, CA*

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[Tre74]	Parameter identification for a model of describing a controlled physical system. *Fa. Hartmann & Braun, Frankfurt/Main*
[Kra78]	Optimization of a complex socioeconomic system. *Industrieseminar der Universität Mannheim*
[Hec79]	Optimization of simulation models. *Kernforschungsanlage Jülich*
[Kra79]	Optimized model of the economic and social changes in the Federal Republic of Germany. *Industrieseminar der Universität Mannheim*
[Lei82]	Optimization of decision parameters in energy models. *Kernforschungsanlage Jülich*
[NHG84]	Parameter identification for a simulation model of the CO–concentration in Madrid. *Laboratoire d'Hydraulique, Ecole Polytechnique Federale, Suisse*

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[Spu84] Top-down computation within budgetting models.
Fachbereich Wirtschaftswissenschaften, TU Berlin

[RAB86] Parameter identification for a model of the progression of a viral disease in mice.
Zentralinstitut für Mikrobiologie und Experimentelle Therapie, Jena

[PC88] Parameter identification for a model of wide-area cattle movement in Australia.
Centre for Arid Zone Research, CSIRO Division of Wildlife and Ecology, Australien

[Kah91] Multicriteria system identification and synthesis of controllers.
Lehrstuhl für Steuerung und Regelung, Universität Dortmund

(Gol85) Dynamic pipeline control by classifier systems.

(Kar91b) Dynamic cart-pole balancing problem. Controller working with fuzzy logic.
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(NR91) Comparison of different optimization techniques in a hydraulic tank control problem.
CEC, ISPRA, Italien

(Thr91) Dynamic cart centering problem. GA learns fuzzy rules.
Texas Instruments Central Research Laboratories, Dallas, Texas

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[SRB76] Design of blood pumps with a low degree of blood damages.
Innere Medizin II der RWTH Aachen

[Bru77] Optimal control of full arm protheses.

[PKZ91] Setting the electrical nerve stimulation for the individual medical treatment of angina pectoris.
Institut für Physiologie, Freie Universität Berlin

[PKZ80a]
[PKZ80b] Identification of the individual frequency and amplitude for the electrical stimulation of the cardiac muscle in case of angina pectoris and hypertension therapy.
Institut für Physiologie, Freie Universität Berlin

[Sch82] Parameter identification of non-linear regression functions applied to the concentration pattern of antibiotics and the integrated Michaelis-Menten equation.
Klinikum Steglitz, Freie Universität Berlin

[JB85] Parameter optimization of a model of ultrasonic adsorption by amino acids.
Zentrum Physiologie, Medizinische Hochschule Hannover

[NV86]
[NV87] Adaptive control of the Functional Electrostimulation (FES) of paralyzed limbs.
Systemtechnische Entwicklung 2, Siemens AG, Karlsruhe

(SWW91) Patient triage by classifier systems.
Denver Dept. of Health and Hospitals

7 Microelectronics

[Hil90] Design of minimal sorting networks.
Thinking Machines Corporation, Cambridge, USA

[Hul92a] Partition of integrated circuits.
Siemens AG, München

[BFG92] Optimized blocking capability of a high voltage planar pn-junction with five-stepped field plate and a channel-stopper.

[GW93] Solving the one-dimensional steady-state basic semiconductor equations (demonstrated for a diode).
Identification of a virtual interface trap by volume traps in the space charge region of a MOS-system.

(Fou85) Optimization of the compaction process, i.e. the generation of mask layouts from symbolic layout (applied to NMOS-technology).

(Chu89) Optimization of stack filters, i.e. nonlinear digital signal processing elements.
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(CMR91) k-partitioning problem in VLSI-design using a coarse-grain parallel GA.

(Hul91) Partition of integrated circuits.
Siemens AG, München

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[BR81] Fitting a contour detection algorithm to special contours of pictures.
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[RB84] Restricting the search space for pattern recognition of overlapping workpieces.
Production Engineering Laboratories, Siemens AG München

[KFH85] Generating reference objects for automatic pattern recognition of unordered, partially hidden workpieces.

[Ebe88] Pattern recognition with neural networks.
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[Loh92]
[Hul92b] Structure optimization of a visual filter to detect the number of coherent areas.
Section Bionics and Evolution Techniques, TU Berlin

(Eng85) Identification and classification of noisy patterns by classifier systems.

(ABP90) Identification of oceanic features in the North Atlantic by combining function evaluation from semantic nets with fuzzy fitness functions.
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(BBR92) 2-D object recognition and estimation of object position, magnification, and orientation from sensor data.

(Cal91) Pattern recognition with binary only-phase filters. Optimization of signal to noise ratio.

(KMS91) Generation of layouts for network diagrams. Parallel implementation on a connection machine.
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(RL91) Extraction of geometric primitives from sensor data. Minimal representation of basic elements and application to pattern recognition.

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9 Artificial Intelligence

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[HE90] Weight optimization of neural networks.
Research and Development Department, Siemens AG, Munich

[Pra90] Configuration of synaptic parameters of a hardware-simulator of neural networks.

Institute of Microelectronics, TU Berlin

[SM90] Determination of the optimal structure of neural networks.
Central Institute of Cybernetics and Information Processes, Academy of Sciences, Berlin

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(CD89) Weight optimization in electrooptical neural networks. Application to XOR and parity problem.

(HSG89) Topology optimization of neural networks. Application to pattern recognition.

(MD89) Training of feedforward nets by Genetic Algorithms.

(MTH89) Topology optimization of neural networks.
BBN Systems and Technologies Corporation, Cambridge, MA

(Hei90)	Weight optimization in neural networks. *Research and Development Department, Siemens AG Munich*
(BB91a)	Parameter optimization and weight optimization in neural networks. Application to an encoder-example.
(BG91)	Genetic Algorithm as learning algorithm in neural networks. Application to XOR-problem. *Deutsches Elektronen-Synchrotron (DESY)*
(Hei91)	GA as learning method for neural networks.
(HS91b)	Topology optimization of backpropagation networks for elimination of units and connections. Application to pattern recognition, XOR and function approximation.
(HS91a)	Topology optimization of backpropagation networks. Application to face recognition.
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(Mon91)	Parameter optimization and weight optimization of backpropagation networks. Application for detection, classification and characterisation of sonar-signals.
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(Tor91)	Topology optimization and weigth optimization of neural networks.
(WDD91)	Weight optimization in neural networks. Application to the dynamical pole balancing problem.
(Mar92)	Topology optimization and weigth optimization of neural networks.
{FFP90}	Weight optimization in neural networks. Comparison to backpropagation. Application to XOR and gasoline blending problem. *ORINCON Corporation, San Diego, CA*
{Aus92}	Topology optimization of neural networks. Application to XOR example problem.
{McD92}	Training of neural networks by Evolutionary Programming methods instead of back-propagation. Consideration of weight constraints. *Naval Command, Control and Ocean Surveillance Center, RDT & E Division, San Diego, CA*
{Por92}	Training of neural networks by Evolutionary Programming methods instead of back-propagation. *ORINCON Corporation, San Diego, CA*
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<SJW91>	Topology optimization of backpropagation networks by an evolutionary method (not exactly a GA). Parallel implementation in a LAN.

10 Production Planning

[Sch76] Solving allocation problems according to Bellman & Dreyfus.
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Fachgebiet Bionik und Evolutionstechnik, TU Berlin

[Abl79]
[Abl87] Solving a traveling salesman problem with 120 cities.
Optimized load planning for more than 100 machines.
Wirtschafts- und Sozialwissenschaftliche Fakultät, Ruprecht-Karl–Universität Heidelberg

[Hen86] Optimization of the traveling salesman problem, timetable problem, knapsack problem, and clique forming problem.
Fachbereich Informatik, Universität Dortmund

[NKLP86] Optimized throughput of logistic conveying systems.
Institut für Transporttechnik und Warendistribution (ITW)

[Hau88] Optimized placement of working points for plastics processing.
Institut für Kunststoffverarbeitung

[Wer88] Solving the $[m/n/P/C_{\max}]$ permutation flow problem.
Sektion Mathematik, TU Otto-von-Guericke, Magdeburg

[BBH+90] Identification of optimal machine setup for an injection molding device of thermoplastics.

[HHKT90] Optimal design of screw conveyers for the extrusion of thermoplastics.
Institut für Kunststoffverarbeitung

[SH92] Optimization of order sequence planning and deadline planning problems in engine production by coupling expert systems and Evolution Strategies.
Klöckner-Humboldt-Deutz AG, Köln

(Dav85) Job shop scheduling.

(HLP+87) Job shop scheduling by classifier systems. Minimization of delay times.
Martin Marietta Energy Systems, Inc.

(WSF87) TSP (Oliver's 30, Eilon's 50, 75 cities) with edge recombination operator. Job shop scheduling, GENITOR-algorithm.
Hewlett-Packard Produktionslinie, Fort Collins, CO

(CS89) Special form of the job shop scheduling problem (flow-shop), which can be modelled as a TSP. New permutation operators ("chunking").

(HMW91) Job shop scheduling and process optimization.

(JB91) Partitioning problem (N objects into k groups). Comparison of several different problem encodings.
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(Nak91) Job shop scheduling, minimization of total working time.
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(VM91) Linear transportation problem with specialized data structures and recombination/mutation operators.

(WSS91) Job shop scheduling (production line). Use of special edge recombination operators (TSP).
Hewlett-Packard Production, Fort Collins, CO

(DP92) Job shop scheduling.

(Kop92) Minimization of freight rate for road transportation according to German regulations.

(Möc92) Integrated software approach to job shop scheduling based on optimization by a Genetic Algorithm.

11 Robotics

[Die92] Solving the nonlinear closure equations for the automatic computation of arbitrary spatial mechanisms for roboter control.

[Woe92] Geometric placement of components of assembly cells with minimized processing periods.

(Dav91c)
(Dav91b) Parameter optimization of robot trajectories for minimization of the positioning error of the end effector. Use of gene deletion and gene duplication, variable length strings.

(Dav91a) Optimization of mechanical manipulators w.r.t. the mechanical positioning error.

{MP90} Path planning for mobile robots using Evolutionary Programming.
Naval Ocean Systems Center

{FF90} Optimal routing of autonomous underwater vehicles through Evolutionary Programming.
ORINCON Corporation, San Diego, CA

{AMP92} Reduction of kinematic redundancy in path planning for mobile manipulators by introducing an equality constraint.
Naval Command, Control and Ocean Surveillance Center, RDT & E Division, San Diego, CA

{MAPP92} Determination of near-optimal mobile manipulator configurations. Objective function incorporates multiple criteria by using a weighted sum.
Naval Command, Control and Ocean Surveillance Center, RDT & E Division, San Diego, CA, and CESAR Lab/ORNL, Oak Ridge, TN

{PMA92} Path planning for mobile robots using Evolutionary Programming.
Naval Command, Control and Ocean Surveillance Center, RDT & E Division, San Diego, CA

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12 Mining

[Wei89] Regression analysis of simulation results for a conveying system.
Institut für Bergbauwissenschaften, TU Berlin

(Kar91a) Optimization of control parameters of a mineral separator in order to maximize the degree of separation for the goal mineral.
U.S. Bureau of Mines

13 Telecommunications

[ZR86] Optimal radiation characteristic of linear unit antenna arrays.
Institut für Grundlagen und Theorie der Elektrotechnik, TU Graz

[Wan87] Maximized merit factors of autocorrelated bit sequences.
Max-Planck–Institut für Biophysikalische Chemie, Göttingen

[GWH89] Optimization of autocorrelated bit sequences.
Interdisziplinäres Projektzentrum für Supercomputing, Eidgenössische Technische Hochschule Zürich

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(CD87) Optimization of the node connections in a telecommunications-network (routing, connections, capacities, transmission rate, network load, network traffic).
Bolt Beranek and Newman (BBN) Laboratories

(DC87) Optimization of the node connections in a telecommunications-network (routing, connections, capacities, transmission rate, network load, network traffic).
Bolt Beranek and Newman (BBN) Laboratories

(CDQ91) Dynamical control problem of routing in telecommunications-networks with respect to available capacities.
Bolt Beranek and Newman (BBN) Laboratories

(LP91) Set-covering problem for diagnosis of multiple errors in microwave communication.
Communication Alarm Power System (CAP), Oak Ridge National Laboratory for the Bonneville Power Administration

(Müh93) Maximized merit factor of autocorrelated bit sequences.
GMD, St. Augustin

{Fog93b} Finding efficient codes for transmissions.
ORINCON Corporation, San Diego, CA

14 Supply and Disposal Systems

[ERS76] Optimized design of a centralized hot-water heater plant.

[CK77] Optimization of local water supply systems.
Institut für Siedlungswasserwirtschaft, Universität Karlsruhe

[Fal80] Optimal choice of location of local waste disposal systems.

[Sch80] Optimized decision parameters in energy models.
Kernforschungsanlage Jülich

[Sch81a] Design of a cabling system with minimal costs.
Central Institute of Cybernetics and Information Processes, Academy of Sciences, Berlin

[Son82] Optimized throughput of power plant cycles.
Deutsche Babcock AG, Oberhausen

[FM83] Optimized power flow in electrical energy supply networks.

[MP83]
[Mül83]
[MTW84] Optimized power flow in electrical energy supply networks.
Institut für Elektrische Anlagen und Hochspannungstechnik, TU Wien

[Ade85] Optimal load management in a network of power plants with discrete load allotments.
Kraftwerk Union AG, Erlangen

[Wag85] Optimized load balancing in a network of power plants.
Siemens AG, Erlangen

[BD92] Multi-criteria decision making fo rthe Khlong Chao Phraya interbasis transfer in Thailand.
Dept. of Water Resources, Wageningen Agricultural University, The Netherlands

15 Military Applications

[Gai78] Optimized range of operation of ballistic missiles.
Minimization of drift sensivity to cross wind of short range tank defense weapons.

Messerschmitt-Bölkow-Blohm GmbH, Ottobrun

[Gai79] Optimized range of operation of a gliding boost missile.
Stability optimization of a ballistic missile.
Optimization of the trajectory of a missile with end phase control.
Messerschmitt-Bölkow-Blohm GmbH, Ottobrun

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(BC89) Airplane optimization as a parameter optimization problem. Optimization of a special air battle mission.
Lockheed Aeronautical Systems Co., Burbank, CA

(BB91c) GA for airplane-optimization w.r.t. special task requirements (air battle mission).

(Gre91) Optimization of symbolic strategies for an airplane control problem under missile attack conditions. Incorporation of domain-specific knowledge and restrictions.
Navy Research Laboratories

(Sys91) Scheduling problem for F-14 flight simulator to pilots. Certain restrictions (resources, times, priorities).
U.S. Navy System Integration Test Station (SITS)

(SP91) Scheduling problem for F-14 flight simulator to pilots. Certain restrictions (resources, times, priorities).
Bolt Beranek and Newman (BBN) Laboratories

{LH92} Evolutionary Programming for planning the tactical employment of antiradiation missiles, i.e. determination of launch parameters which maximize effectiveness of weapons against SAM radars while minimizing risk to launch aircraft from other threats.
Naval Ocean Systems Center, Decision Support and AI Branch, San Diego, CA

{Rub92} Case generalization in expert systems by EP. Application to a naval battle management problem.
Naval Ocean Systems Center, San Diego, CA

16 Miscellaneous Applications

[Noo71b] Solving an analytically intractable set of equations.
Zentrallaboratorium für Datentechnik, Siemens AG

[See76] Optimized results from a model of economy to determine future tax volumes.
Fachbereich Kybernetik, Universität Berlin

[See77] Identification of the optimal policy within a macroeconomic model.
Fachbereich Kybernetik, TU Berlin

[SW78] Optimal policy within an econometric model of the economy of the United States.

[Ham81] Minimized interchange delays in a local traffic network.

[Rep85] Approximate solutions of the set-cover problem.
Fachbereich Mathematik/Informatik, Universität-Gesamthochschule Paderborn

[Mül86]	Optimal design of glas fibre optics, lamps, and heater circuits. Optimized tolerance of gear units. Optimal recipes for porcelain manufacturing. Optimal noise reduction of axial fans. *Fachbereich Verfahrenstechnik, TU Berlin*
[Ban88]	Finding suitable coefficients to describe π by means of regular and irregular continued fractions. *Institut für Theoretische Physik und Synergetic, Universität Stuttgart*
[KSW88]	General method for optimizing decision parameters in a Decision Support System (DSS). *Central Institute of Cybernetics and Information Processes, Academy of Sciences, Berlin*
[Rec89]	Solving magic squares. Simulated evolution of optical lenses. *Fachgebiet Bionik und Evolutionstechnik, TU Berlin*
[Har91]	Characterization of fissurations in cross-grain attacked rotors for determining their reusability.

(Smi85)	2-dimension packing problem. Representation of packing sequences by permutations. *Texas Instruments Computer Science Laboratory*
(JS87)	SAT (satisfiability of boolean expressions). Mapping of the TSP to SAT.
(HMS89)	Optimization of Steiner trees (network topologies).
(dlM89)	Rule-based system for profit-forecasting in horse-races.
(Müh89)	Quadratic assignment problem using a fine-grain parallel GA.
(PTS89)	Integration of expert systems and GA for solving engineering problems. Utilization for design of cooling fans, molecular electronic structures and airplane nozzles. *General Electrics Research and Development*
(BFI91)	Simplification of complex queries in database systems.
(CDM91)	Timetable problem.
(CJ91)	Construction of identikit pictures based on components selected by a witness. *National Institute of Justice, U.S. Department of Justice*
(GBH+91)	Optimization of the distribution of trains to tracks, including time scheduling (transportation problem). *CSX Transportation, Baltimore MD*
(HG91)	Thematic bridging between music patterns by a GA. Start pattern and goal pattern are predefined, and the GA composes by minimization of the distance between the patterns.

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(KSV91) 2-dimensional container packing problem.

(vLM91) k-way graph partitioning problem using a fine-grain parallel GA.

(MF91) Allocation of processes to MIMD-processors in order to minimize the total program execution time.
Joint Tactical Fusion Program Office, National Science Foundation

(SL91) Sliding puzzle problem.

(Wya91) Generation of context-free grammars in Greibach normal form by using test examples. Evaluation w.r.t. the number of correct classified strings.
Speech and Language Technology, BT Laboratories, Ipswitch, England

(Jul92) Truck packing (pallet loading) problem.

{Moo92} Development of a system for locating buried ferrous objects by use of EP.
ORINCON Corporation, San Diego, CA

<BHS89> Quadratic assignment problem. Utilization of a parallel hybrid of Simulated Annealing and GA.

<Nis92> Quadratic Assignment Problem.

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