Emmanuel Livshits

Education:

- Ph. D. degree in Computer Science (1969)
- Department of Computer Science, Research Institute of Theory and Applications of Low Temperature Physics, Ukrainian Academy of Sciences, Kharkov, USSR
- Master's degree in Mathematics (1962)
- Kharkov University, Kharkov, USSR

Citizenship:

Citizen of the United States

I. Professional Experience

1999 – present Consultant (the resent for Wingas (Germany)

1994 - 1999 Chief Scientist
Future Graph, Inc.
Southampton, PA 19096
Educational Software

1992 - 1994 Consultant
ALP Inc.
Wynnewood, PA 19096
Universal Data Base Visualization Tool

1989 - 1992 Chief Scientist Omnifont Page Recognition Software System
OCR Systems, Inc.
Huntingdon Valley, PA

1981 - 1988 Head of Computer Operations, Data Base Administrator
Data Processing Center, Ministry of Light Industry
Tbilisi, Georgia, USSR
Management Information Systems

1978 - 1981 Project Leader
Institute for Automation of Heavy Industry
Kharkov, USSR
Automatic Planning and Control System for Natural Gas Pipeline

1962 - 1978 Senior Scientist, Scientist
Department of Computer Science
Research Institute of Theory and Applications of Low Temperature Physics,
Ukrainian Academy of Sciences, Kharkov, USSR
Project Leader (1962 - 1978)
Statistical Modeling Software Package for Ray Tracing
Project Leader(1972 - 1978)
Fully Automated Computer Aided Design System for Kharkov Machine
Tool Manufacturing Plant
Scientist (1970 - 1975)
Bio-Medical Applications

II. Publications

Articles on Discrete Mathematics

Combinatorics, Automata and Graph Theory

1. An asymptotic formula for the number of classes of isomorphic autonomous automata with n states. Ukrainian Mathematical Journal, No. 2, 245-246 (1964).
2. Minimal universal trees. (With M. K. Goldberg). Mathematical Letters, Vol. 4, No. 3, 371-379 (1968)
3. Bounds for the weight of a regular expression over a one-letter alphabet. (With J. I. Ljubich). Siberian Mathematical Journal, 122-126. (1965).
4. Enumeration of the number of states of isomorphic automata with n states and k inputs. Works of Kiev Institute of Cybernetics, Automata Theory Series, (1965) .
5. Reconstruction of a graph using its fragments -- Conference Report in Batumi in 1986.

Discrete Optimization

6. The problem of minimization the sum of penalties in scheduling. (With G. K. Kladov). Journal of Cybernetics (Kiev) no. 6, 99-100 (1968).
7. The optimal system of tests in a selection problem. Collection of Papers on Theory of Optimal Solutions, No. 3, 84-90, (1969) Ukrainian Academy of Sciences, Kiev.
8. The comparative complexity of certain discrete optimization problems. (With V. I. Rublineckii). Works of the Research Institute of Theory and Applications of Low Temperature Physics, Computer Science and Engineering Series, No. 3, 78-85, (1972), Kharkov.
9. The optimal splitting of an ordered set into intervals. (With V. I. Rublineckii). Works of the Research Institute of Theory and Applications of Low Temperature Physics, Computer Science and Engineering Series, No. 3, (1972), Kharkov.
10. An analysis of some algorithms of discrete optimization. Ph. D. Dissertation. Ukrainian Academy of Sciences, Research Institute of Theory and Applications of Low Temperature Physics, Department of Computer Science (1969).
11. An analysis of algorithms for optimization of scheduling of k dependent tasks on n parallel processors. Journal of Economics and Mathematical Methods, Vol. III, No. 5, (1968).
12. Some estimates of error in approximate solution of the problem of optimization of scheduling on parallel processors. Proceedings of the Winter School on Mathematical Programming, No. III, 477-491, Moscow, (1969).
13. Minimization of maximum penalty in the scheduling problem on one processor. Proceedings of the Winter School on Mathematical Programming, No. III, 474-476, Moscow, (1969).
14. The optimal sequence of operations in manufacturing of a complex object. Journal of Automatic Control, Vol. II, Moscow, (1968).
15. Randomization of locally-optimal algorithms for solving discrete problems. (With V. A. Plenkova and V. I. Rublineckii). Works of the Research Institute of Theory and Applications of Low Temperature Physics, Computer Science and Engineering Series, (1969), Kharkov.
16. An order relation in minimal ordering problems. Journal of Cybernetics, no. 3, (1975), Kiev.

Process Automation

17. On optimal cyclical serving of assembly line by multiple robots. (With Z. N. Mihaileckiy). Journal of Control Systems and Machines, No. 3, 8-15, (1977), Kiev.
18. On minimal number of robots for serving an assembly line. (With A. V. Karzanov). Journal of Automatic Control, No. 3, 162-169, Moscow, (1978).
19. The problem of maximizing the productivity of an automated assembly line with one automatic operator. (With Z. N. Mihaileckiy and E. V. Cervjakov). Works of the Research

Institute of Theory and Applications of Low Temperature Physics, Computer Science and Engineering Series, No. 5, 151-155, (1974), Kharkov.

Articles on Algorithms, Models and System Descriptions

Statistical Modeling

20. Calculation of parameters of cryogenic vacuum cameras using Monte-Carlo techniques. (With L. I. Kalashnik and A. M. Kislov). Journal of Engineering Physics , Vol. XIII, No. 6, 904-913, Minsk, (1967).
21. Statistical modeling of thin film coating in vacuum. (With L. I. Kalashnik and A. M. Kislov). Journal of Engineering Physics , Vol. XVIII, No. 1, 140-144, Minsk, (1969).
22. A description of a software package for statistical modeling of transfer processes. (With L.I. Kalashnik and A. M. Kislov). Works of the Research Institute of Theory and Applications of Low Temperature Physics, Computer Science and Engineering Series, (1969), Kharkov.
23. A calculation of effectiveness of the laser illumination system using statistical modeling. (With L. I. Kalashnik and A. M. Kislov). Works of the Research Institute of Theory and Applications of Low Temperature Physics, Computer Science and Engineering Series, (1969), Kharkov.
24. A comparison of efficiency of alternate schemes for statistical modeling of transfer processes.(With A. M. Kislov). Works of the Research Institute of Theory and Applications of Low Temperature Physics, Computer Science and Engineering Series, (1972), Kharkov.
25. Computer Simulation of Space. (With L. I. Kalashnik and A. M. Kislov). Works of the Research Institute of Theory and Applications of Low Temperature Physics, Computer Science and Engineering Series, No. 4, (1968), Kharkov.
26. Physical Foundations of Space Simulation. (With. B. I. Verkin, N. N. Bagrov, A. A. Guslyakov, I. O. Kulik and A. E. Yanov). Collection of Papers on Space Simulation, (1962).

Computer Aided Design

27. On computer generation of single-plane kinematics scheme of gear boxes. (With V. M.Borshevskii, V. A. Plenkova and L. I. Kalashnik). Works of the Research Institute of Theory and Applications of Low Temperature Physics, Computer Science and Engineering Series, (1974), Kharkov.
28. Automated design of gear boxes. (With V. M. Borshevskiy). Machine Tools and Instruments, No. 5, (1977), Kiev.
29. Algorithms for design of connected networks. (With V. Vainer and N. D. Zaicev). Journal of Automatic Control, No. 7, 153-162, Moscow, (1977).

Miscellaneous

30. On a certain game of hide-and-seek. (With L. I. Kalashnik). Works of the Research Institute of Theory and Applications of Low Temperature Physics, Computer Science and Engineering Series, (1969), Kharkov.
31. On application of force on system of levers. (With V. S. Azarin). Works of the Research Institute of Theory and Applications of Low Temperature Physics, Computer Science and Engineering Series, (1969), Kharkov.
32. The influence of fluctuations on electro-magnetic properties of Josephson's tunnel junctions. (With L. I. Kalashnik, I. S. Kulik, K. V. Maslov and A. A. Motornaja). Journal of Engineering Physics, Vol. 42, No. 6, Moscow, (1972).
33. Statistical analysis of arrhythmia in thyrotoxicosis patients. (With V. M. Kirzhner and E. S. Rom-Boguslavskaja). Journal of Cardiology, No. 2, (1973), Moscow.

Recent articles (not included in the list) are devoted to optimization of operational mode of compressor stations in gas networks and modeling of stock market (some formulas for options pricing were established).

XXXIV. Professional Interests

Interests

My professional interests encompass two distinct types of activity. The first is theoretical: I am interested and have obtained some results in several theoretical areas of Discrete Mathematics and Computer Science. The second is the development of software systems for solving applied problems . My applied work usually also involves developing the mathematical models, designing the algorithms and providing the architecture for the final software implementation to solve a particular problem. When necessary, I also participate in the programming.

In addition to purely theoretical work, much of the research I have performed in Theoretical Computer Science and Discrete Mathematics, including Computational Complexity Theory and Combinatorics, was motivated by the problems I have encountered in applications. The theoretical research in, turn, has often helped me in solving practical problems. Of my thirty or so publications, about half are theoretical and half are applied.

Applied problems that I have worked on have come from a wide variety of fields, including Optimal Scheduling, Physics, Engineering, Medicine, Biology, Data Processing, Pattern Recognition, CAD, Artificial Intelligence, Image Processing, Manufacturing and Process Control and Automation. The unifying features of the aspects of the problems I participated in are the complex discrete structure at their core and the fact that the most effective solutions used methods of Discrete Mathematics and Computational Geometry.

Applications

Based on my previous experience in developing software systems I would like to apply my knowledge participating in software systems development for such applications as optimization, image processing, pattern recognition, educational software, optimal planning and control, medical applications and CAD.

In general I am opened to participate almost in any R&D in the fields where there are new and difficult problems.

XXXV. Theoretical Research in Computer Science

Combinatorics, Automata and Graph Theory [1 - 5]

I obtained the formula for enumeration of the number of states of isomorphic automata with n states and k inputs using modified Polya's Method in [4] .

I obtained an asymptotic formula for the number of classes of isomorphic autonomous automata with n states using the generating function for the number of automata by F. J. Murray in [1].

In [3] there were determined bounds for the weight of a regular expression over a one-letter alphabet.

The problem of finding the object of minimal complexity, into which all objects of a certain type are embedded, arises naturally in Graph and Automata Theory (C. Shannon and C. Berge). In [2] it was found the minimum universal rooted tree into which all rooted trees with n nodes are embedded.

Discrete Optimization [6 - 19]

Most of my work in Discrete Optimization concentrated on Scheduling Theory and was inspired by applications. The research proved to be exhaustive in the following sense:

1) all problems solvable by simple list algorithms were described;
2) estimates of error were obtained in cases where such techniques, which yielded only approximate solutions, were applied to complex problems;
3) NP-completeness was established for complex problems that could not be solved efficiently.

Most these results I obtained independently, so they were pioneering for that time. The following paragraphs describe these in more detail.

Smith's rule is generalized and formalized, and a number of new problems that can be solved utilizing this approach are also described [8, 16]. A simple algorithm that solves the problem of minimization of maximum non-decreasing cost function for one-processor problem with independent tasks is obtained [13]. The same algorithm was described by Lawuler for problems with precedence constraints on the tasks. The fact that the descriptions obtained in earlier works incorporate all of the problems solvable by those simple approaches is proved [6, 16].

Error estimates in approximation algorithms have been studied by Graham, Coffman, Belov, Stolin, Sevastianov, and others, and [11, 12] are devoted to investigating the same issues. They establish precise estimates for the size of absolute error produced by approximation algorithms for optimization of scheduling on parallel processors. In the particular case where the task duration is one unit, one of the results implies that the solution obtained by the algorithm is optimal, a well known fact, first discovered by Hu.

Studies of the relative complexity of problems in discrete optimization arising in scheduling theory are described in [8]. (We say that problem A is more complex than problem B if we can solve problem B by linearly transforming it into problem A). This work shows that many widely known problems in scheduling theory that do not have an efficient solution are more complex than the knapsack problem (these include problems formulated by Jackson, McNaughton, Johnson and others). In the light of the work by Cook and Karp establishing NP-completeness of the knapsack problem, [8] establishes NP-completeness of the scheduling theory problems it studied. Some of these results were also obtained by P. Brucker, J.K. Lenstra and A. H. G. Rinnooy Kahn.

I also worked on a Process Automation project for a large manufacturer of printed circuit boards for use in avionics. The project called for creation of a software system for optimal scheduling and control of movement of manufacturing robots on factory floor. I developed original mathematical models and designed the algorithms. The work yielded several theoretical results which were subsequently published [17 -19].

Publications [7, 9, 14, 15, 17-19] are also devoted to analysis of algorithms for discrete optimization.

IV. Software Systems Development

Statistical Modeling [20 - 26]

For Research Institute of Theory and Applications of Low Temperature Physics
One of the first major projects I worked on was simulating conditions that occur in the open space for the Soviet space program. Special cameras were constructed for that purpose. I used Monte Carlo techniques to simulate the particle streams and rays of light inside the camera and probability distributions to describe the deflection and absorption of the particles by the cooling surfaces and the screens.

To simulate the camera environment, I developed a technique for describing camera geometry and a general purpose ray tracing algorithm capable of handling arbitrary geometry for two and three dimensions.

The system was presented at the First International Conference on the Uses of Vacuum Technology in Space Research in Paris in 1964. It subsequently received several awards for technical excellence.

Since both the statistical model and the software architecture of the system were flexible, I later applied them to solve problems that occurred in laser manufacturing for optimization of mirror surfaces. I also applied it to problems in the manufacture of very thin plastic film that had to be coated with various particles in vacuum in order to prevent contamination. I also conducted a feasibility study to see if the system could be used for optimization of radiation therapy in cancer treatment. The conclusion of the study was affirmative.

Computer Aided Design

For Kharkov Machine Tool Manufacturing Plant
The problem was automating one of the most labor-intensive engineering phases in the design of a tool for drilling several arbitrarily arranged holes in a flat piece of metal, the gear shift design for a single-motor drilling machine.

The system I designed worked in three stages. The first stage computed the connective structure of the gear shift and the first approximation of the layout of the gears. The algorithms built optimally-connected networks. The second stage computed the radii and locations of the centers of gears. It met geometrical constraints with a much higher precision than the first stage. This is where the large systems of equations and inequalities occurred. The algorithms used the techniques of group coordinate-wise relaxation, augmented by heuristics to determine the step size and other parameters of the relaxation process.

The third and final stage selected the gears from a pre-specified set. It took into account geometrical and technological (manufacturing) restrictions, physical properties of available materials and the sizes of available components. It produced final engineering drawings that were directly used in the manufacturing of gear shifts.

The resulting system was widely accepted. Its computational core was made available as a stand-alone package and has been incorporated into several other CAD systems. I personally used this package to develop a CAD subsystem for design of new chemical plants. It computed the placement of the connecting pipes.

Gas Networks

For Tashkent Natural Gas Pipeline
My assignment was development of a software system that performed automatic planning and control of the Central Asia Natural Gas Pipeline.

The planning and control system had to perform two main functions. The first was calculating the regime of the pipeline, that is, gas pressure and flows in all of the pipeline sections given the characteristic parameters of all of its elements. The second was the calculation of the optimal operating pump connection structure of the compressor stations to minimize their energy consumption, while maintaining prescribed pressure.

To perform these functions, I designed a knowledge base capable of containing the full description of the graph structure of the pipeline, parameters of all of the elements, as well as the algorithms necessary for computations of work load of the pumps. The object-oriented architecture of the software design then permitted an implicit solution of the large systems of corresponding non-linear equations and inequalities using iterative algorithms of continuous optimization and network algorithms.

The second function, that of choosing the optimal compressor pumps connection structure, was solved using branch-and-bound techniques. This turned out to be efficient because the non-viable branches could be eliminated very early on.

The final system outperformed a competitive system developed by a large software team in the National Ministry of Gas and Oil. It received several awards and was made a part of the exhibit of national technical achievements in Moscow. It has been adopted by other local and national natural gas pipelines in the USSR and is still in use today.

Pattern Recognition and Image Processing

For OCR Systems, Inc
My duties at OCR Systems included design of various image processing and pattern recognition algorithms, as well as management of their software implementation. Algorithms were designed using concepts from Computational Geometry, Graph Theory, Cluster Analysis, formal decision-making techniques, Discrete Optimization and Statistics.
The following is a list of software subsystems for which I developed algorithms and techniques:
Image transformation and noise compensation: calculation of object boundaries and topological structure; several subsystems that compensated for the image noise effects, such as detection and reconstruction of broken curves and filling of dot matrix characters.
Feature extraction: a subsystem for calculation of low-level features using the convex hull of the region and its extrema structures.

Segmentation: object detection in gray and color images; character segmentation including segmenting in the presence of noise (broken and touching characters); a subsystem of the forms recognition product which detected and removed straight lines found on forms; a subsystem for detection of text lines.

Recognition: a character recognition subsystem based on structural description; a system for identification of various image objects and their positions used for aligning skewed forms; subsystem for recognition and processing of character attributes including italic, bold, and underlines.

Control: the recognition process control subsystem which included algorithms for optimal alternative searching, feedback and final decision making.

V. Consulting and Applied Activities

The recent consulting are in the field of optimization of gas networks (Wingas, Germany), stock market analysis, and application of image processing of interferometer pictures and the least square method to calculate parameters of fiber optics connectors (Norland, Inc). There are some publications in these areas, which ate not included in the above list.
MIS

For Georgian Ministry of Light Industry
I designed and developed the central data base for the Ministry and functioned as its administrator. The DBMS that I used to design the Ministry's data base had a hierarchical structure, based on IMS architecture. I designed the data base structure, queries, searching routines, data entry and the user interface programs. I performed the software development for the data base, from programming to final installation and maintenance.

Biology and Medicine [33]

For Kharkov Cardiological Clinic
Automated monitoring system for Intensive Care Units. I developed the model and algorithms for an automatic system to monitor the vital parameters of the recovering heart-attack patients in an ICU. It continuously monitored the cardiograms in order to predict conditions serious enough to summon medical attention. It then reported such conditions to the nursing station.

For Moscow Institute for Space Medicine
Automatic warning system for emergencies in spaceship life-support systems. I developed the model and algorithms for a system that continuously monitored cosmonaut's vital signs, such as blood pressure, pulse and temperature. When it detected a potential for an emergency, it warned

the Earth control center to enable it to intervene and modify the parameters of the life-support system of the ship before any catastrophe occurred.

For Kharkov Institute of Endocrinology
I designed a system that read and interpreted the cardiograms of the patients with arrhythmia. It utilized a phenomenological model of arrhythmia to provide diagnoses of various types of arrhythmia. I also developed a system that computed optimal drug dosage and delivery frequency for thyrotoxicosis and diabetes patients.

For Kharkov Institute of Trauma and Orthopedic Emergency Medicine
I performed the statistical analysis for the study of the correlation of blood and tissue types in humans.

Applied Physics and Scientific Programming
For Research Institute of Theory and Applications of Low Temperature Physics.
My routine duties at the institute involved statistical analysis of the results of various experiments conducted by different departments. I also performed scientific computations for models of different physical processes that were being researched at the institute.
I developed efficient algorithms to solve the traveling salesman problem which came up in the system for optimal control of automatic drilling machines.
I developed algorithms for a software system used for planning the optimal locations for a set of distribution centers for the construction industry. The system minimized travel times for trucks. I used techniques of Linear Programming and Discrete Optimization.

For Research and Development Institute for Hydroelectric Power-Generating Stations
The problem was predicting the time and intensity of river floods. I developed the stochastic model and the corresponding algorithms using Fourier Transform and the Method of Least Squares to compute the parameters of the model. Based on the success of the experiments using the model, it was accepted as part of the methodology for development of hydro-electrical power stations.