

Curriculum Vitae

David Malah

Personal Data

Date and place of birth: March 31, 1943, Poland
Immigration to Israel: 1949
Marital Status: Married, 1 Child, 2 Grandchildren
Citizenship: Israeli

Academic Degrees

B.Sc. Technion, EE Dept. – Haifa, Israel, 1965 (cum laude)
M.Sc. Technion, EE Dept. – Haifa, Israel, 1968 (with distinction)
Ph.D. University of Minnesota, EE Dept. – Minneapolis, Minn., USA, 1971
(Minor: Math)

Academic Appointments

2011 Professor Emeritus, Technion, Department of Electrical Engineering
1989 Professor, Technion, Department of Electrical Engineering
1981 Associate Professor, Technion, Department of Electrical Engineering
1977 Senior Lecturer, Technion, Department of Electrical Engineering
1972 Lecturer, Technion, Department of Electrical Engineering
1971 Assistant Professor, University of New Brunswick (UNB), Department of Electrical Engineering, Fredericton, New Brunswick, Canada.
1970 Lecturer, UNB (while completing Ph.D. Thesis at University of Minnesota).
1967 Teaching Associate, University of Minnesota, Department of Electrical Engineering, Minneapolis, Minn. USA (Doctoral candidate).
1966 Teaching Assistant, Technion, Department of Electrical Engineering (M.Sc. student).

Teaching Experience

Technion, Department of Electrical Engineering:
Electronic Circuits - Tutorials and Laboratory: October 1966 to June 1967
University of Minnesota, Department of Electrical Engineering:
Electronic Circuits - Tutorials and Laboratory: Sept. 1967 to August 1970

University of New Brunswick, Department of Electrical Engineering:
 Basic Electrical Engineering and Electronic Circuits: Sept. 1970 to June 1972
 Graduate course in Digital Signal Processing: January to June 1972

Technion, Department of Electrical Engineering:

Undergraduate courses

Linear Electronic Circuits: 1973
 Electronic Switching Circuits: 1973–78
 Digital Systems: 1975–76
 Signals and Systems: 1978–79, 1981–83
 Introduction to Digital Signal Processing: 1982–86, 1997–2000
 Basic Circuit Theory: 1989–90
 Image Processing and Analysis: W-2002/3, S-2004
 Academic Supervisor of all EE instruction Labs (EE-Labs - 1,2,3,
 Projects-Labs - A, B, Special project): 1999–00, 2003–2010
 Digital Signal Processing (shared with graduate program): 2005–2010

Graduate courses

Digital Signal Processing: 1973–79, 1981–88, 1989–95, 1996–2000, 2001–2010 (since 2005 a shared course with UG)
 Selected Topics in Signal Processing: 1976–79, 1982–88, 1990–91
Main Topics: Speech and Image Coding; Adaptive Filtering; Speech and Image Analysis
 Digital Coding of Speech Signals and Images: 1992–95, 1997–2000, 2001–2007
 Video Signal Processing: S-2008, S-2009, S-2011, S-2012
 Laboratory in Signal Processing: 1977–79, 1982–88, 1989–95, 1997–2000, 2001–2010

Research Experience

1972–79, 1981–88, 1989–95, 1996–2000, 2002–

Technion, Electrical Engineering Department:
 Digital Signal Processing, Digital Speech and Image Communication
 Speech and Image Processing, Speech and Image Enhancement
 Morphological, Fractal and Wavelet Image Coding
 Digital Speech and Audio Coding, Watermarking
 Video Processing, Coding and Transcoding
 Hyperspectral Image Coding and Analysis
 Text-to-Speech Synthesis (TTS) and Voice Conversion
 Processin of 3D Point-Clouds

Summer 1978

Motorola Inc., Communication Division, Schaumburg Ill., USA
 Digital Speech Communication: Speech Compression.

1979–81 (Sabbatical and Leave of Absence) and Summers 1983, 1986

AT&T Bell Laboratories, Acoustics Research Dept., and Signal Processing
 Research Dept., Murray Hill, NJ, USA
 Digital Speech Communication: Time and Frequency Domain Harmonic Scal-
 ing, Speech Analysis and Coding.

1988–89 (Sabbatical) and Summer 1991

AT&T Bell Laboratories, Signal Processing Research Dept.,
Murray Hill, NJ, USA
Digital Image Processing: Image Sequence Coding for Video Conferencing and
Storage Applications.

Summer 1993

AT&T Bell Laboratories, Speech Coding Research Dept.,
Murray Hill, NJ, USA
Digital Speech Communication: Time-Scale Modification and Coding of Speech
Signals.

8/1995–2/96 (Sabbatical)

AT&T and Lucent Technologies - Bell Laboratories,
Signal Processing Research Dept., Murray Hill, NJ, USA
Digital Image Processing: Video Preprocessing for Improved Coding Quality
at Low Bit-Rates.

3/1996–9/96 (Sabbatical)

AT&T Labs - Research, Speech and Image Processing Lab,
Murray Hill, NJ, USA
Digital Speech Communication: Speech Enhancement.

Summer 1998

AT&T Labs - Research, Speech and Image Processing Lab,
Murray Hill, NJ, USA
Digital Speech Communication: Speech Enhancement.

10/2000–9/2001 (Sabbatical)

AT&T Labs - Research, Speech and Image Processing Lab,
Florham Park, NJ, USA
Digital Speech Communication: Bandwidth Extension of Narrowband Speech.

Summer 2004

GCATT - Georgia Centers for Advanced Telecommunication Technology,
Georgia Institute of Technology, Atlanta, GA, USA:
Digital Video Processing.

Summer 2011

Electrical and Computer Engineering Dept., College of Science and Engineer-
ing, University of Minnesota, Minneapolis, MN, USA
Text-to-Speech Synthesis In the Era of Mobile Devices.

Other Professional Experience

Israel Defense Forces: Electronics Engineer, 1964–66

Science Based Industry in Israel (Elbit Systems Ltd., Tadiran – Communication Div.,
Motorola-Israel, Rafael, Zoran, DSPG and others):

Consultant in Signal Processing Applications: 1973–79, 1984–88, 1990–94, 1998–2000, 2007

AT&T Bell Laboratories, Acoustics Research Dept., Murray Hill, N.J. USA:

Member of Technical Staff: 1980–81 (while on leave from the Technion):

Digital Speech Communication.

Administrative Posts

- Head, Signal and Image Processing Laboratory (SIPL) (Technion, EE Dept.): 1975–79; 1981–88; 1989–95; 1996–2000; 2001–
- Coordinator and member of the Undergraduate Curriculum Committee (Technion, EE Dept.): 1984–85 (coordinator); 1989–93 (coordinator); 1994–95 (member).
- Coordinator and member of Graduate Studies (Technion, EE Dept.): 1986–88 (coordinator); 1999–2000 (member).
- Member of the Standing Committee for Undergraduate and Graduate studies of the Technion's Senate: 1986–88.
- Member of the Graduation Committee of the Graduate School (Technion): 1990.
- Member of the Awards Committee of the Graduate School (Technion): 1991–93.
- Member of the Technion's Senate Committee for Senior Appointments and Tenure: 7/1994–7/95, 1997.
- Member of Technion's Advisory Committee to the Vice-Provost for Research on Future Research Directions: 8/1999–12/99.
- Academic supervisor of the EE departmental library: 07/2002–06/2008.
- Member of the joint academic-staff - Students committee, EE Dept.: 2002–2007.
- Member of Technion's Research Committee: 2003–2005.
- Member of Technion Senate Search Committee for Technion-wide Deans: 10/2004–10/2007.
- Member of Technion students' disciplinary court: 1/2005–3/2010
- Member of the Technion senate steering committee: 12/2005–12/2007.
- Member of Technion's new Senate: 2006–
- Director, Departmental Center for Communication & Information Technologies - CCIT, and head of Industrial Liaison Program: 1/2006–4/2010
- Chair of departmental Projects Competition committee: 2003–2010
- Member of departmental Labs Development committee: 2007–2010
- Member of Technion's Senate Ad-Hoc committee for the appointment of VP's that are not Senate members 2009–2010.

Presentations at Conferences/Workshops/Seminars

- 13th Midwest Symposium on Circuit Theory, Minneapolis, Minnesota, USA, May 1970, “Synthesis of Linear Discrete-Time-Varying System from Impulse Response Specifications” (See conference paper No. 1 in conference-papers list below).
- 9th IEEE Convention, Tel-Aviv, Israel, April 1975, “Time Limited Signal Interpolation by Means of the FFT” (See conference paper No. 2 in conference-papers list below).
- 10th IEEE Convention, Tel-Aviv, Israel, Oct. 1977, “Digital Harmonic Compression of Speech Signals in the Time Domain” (See conference paper No. 3 in conference-papers list below).
- International Conference on Acoustics, Speech and Signal Processing (ICASSP-80), Denver Colorado, USA, April 1980, “Time Domain Harmonic Compression of Speech Signals” (See conference paper No. 9 in conference-papers list below).
- Acoustical Society of America—99th Meeting, Atlanta, Georgia, USA, April 1980, “Performance of Transform and Sub-band Coding Systems Combined with Harmonic Scaling of Speech” (Preliminary results, expanded in article No. 8 in papers list below).
- Acoustical Society of America—100th Meeting, Los Angeles, California, USA, Nov. 1980, “Efficient Implementation of a Frequency-Domain Technique for Frequency Scaling of Speech Signals” (Preliminary results, expanded in article No. 10 in papers list below).
- International Conference on ASSP (ICASSP-81), Atlanta, Georgia, USA, March 1981, “Spectral Matching of LPC Residual Signal” (See conference paper No. 10 in conference-papers list below).
- International Conference on ASSP (ICASSP-82), Paris, France, May 1982, “A Generalized Comb Filtering Technique for Speech Enhancement” (See conference paper No. 12 in conference-papers list below).
- International Conference on ASSP (ICASSP-82), Paris, France, May 1982, “Cepstral Residual Vocoder for Improved Quality Speech Transmission at 4.8 Kbps” (See conference paper No. 13 in conference-papers list below).
- The Weizmann Institute of Science, Dept. of Applied Mathematics, Rehovot, Israel, Jan. 3, 1984, “Digital Compression of Speech Signals for Transmission in Narrow-band Channels”.
- 15th IEEE Convention, Tel-Aviv, Israel, April 1987, “Novel Approaches to Residual Speech Coding” (**Invited** opening lecture). (See Also Public Professional Activities below).
- Acoustical Society of America—116th Meeting, Honolulu, Hawaii, USA, Nov. 1988, “Efficient Subband Coding of Speech with Optimized Uniform DFT Filter Banks”. (Preliminary results, expanded in article No. 21 in papers list below).
- AT&T Bell Laboratories, Murray Hill, NJ, USA, Sept. 27, 1989, “Improvements in Hybrid Image-Sequence Coders for Storage Applications”.
- Yale University, Electrical Eng. Dept., New haven, CT, USA, Aug. 26, 1991; Tel-Aviv University, Electrical Eng. Dept. -Systems, Nov. 11, 1991, “Morphological Image Coding” (Preliminary results, expanded in article No. 26 in papers list below).

- Geroge Mason University, Fairfax, VA, USA, Electrical and Computer Eng. Dept., Aug. 30, 1993; AT&T Bell Laboratories, Murray Hill, NJ, USA, Sept. 9, 1993 "Global Motion Estimation in Image-Sequences of 3D scenes for Coding Applications".
- AT&T Bell Laboratories, Murray Hill, NJ, USA, Sept. 28, 1993, "A Unified Representation and Improvements in Time-Domain Algorithms for Time-scale Modification of Speech".
- The Samuel Neaman Workshop on Signal and Image Representation in Combined Spaces, Haifa, Israel, May 1994, "A Pyramidal approach for Fractal Image Coding" (**Invited**).
- International Conference on Pattern recognition (12th ICPR), Jerusalem, Israel, Oct. 1994, Member of Panel on "Computer Vision and Image/Video Compression", Panel presentation on: "Global Motion Compensation and Change Detection" (**Invited**).
- AT&T Bell Laboratories, Murray Hill, NJ, USA, Oct. 5, 1995; Rutgers University, CAIP Center, Piscataway, NJ "A Multiresolution Framework for Fractal Image Representation and Coding".
- AT&T Bell Laboratories, Murray Hill, NJ, USA, Aug. 20, 1998, "Speech-Enhancement Preprocessing for Speech Coding in Noisy Environments" (Preliminary results, expanded in article No. 35 in papers list below).
- IEEE–Israel, Signal Processing Society Chapter, and Technion–Signal and Image Processing Lab Workshop, Haifa, Israel, June 2000, "Fractal Image Coding in the Discrete Wavelet Transform Domain".
- AT&T Labs, Florham Park, NJ, USA, Jan. 31, 2001, "Applying Approximate Solutions of the Travelling Salesman Problem to the Compression of Color-mapped images and Codebook Index assignment".
- International Conference on Acoustics, Speech and Signal Processing (ICASSP-2001), Salt-Lake City, Utah, USA, May 2001, "Improved Lossless Compression of Color-Mapped Images by an Approximate Solution of The Travelling Salesman Problem" (See conference paper No. 83 in conference-papers list below).
- AT&T Labs, Florham Park, NJ, USA, Sept. 24, 2001, "An Interpolative Approach to bandwidth Extension of Narrowband Speech".
- CCIT - Center for Communication and Information Technologies, EE Dept., Technion - Innovations in Signal & Image Processing Workshop, Haifa, Israel, May 2003 "Review of Research Activity at the Signal and Image Processing Lab".
- IBM Speech Technology Seminar, IBM Haifa Research Labs, Israel, "Speech coding at very low bit rates", June 2003 (**Invited**).
- AT&T Labs, Florham Park, NJ, July 26, 2004; Georgia Institute of Technology - GCATT (Georgia Centers for Advanced Telecommunications Technology), Atlanta, GA, Sept. 24, 2004, "Data Embedding in Speech Signals with Application to Bandwidth Extension of Telephone Speech".
- Georgia Institute of Technology - GCATT, Atlanta, GA, USA, Sept. 3, 2004, "Transrating of Coded Video Signals via Optimized Requantization".
- Georgia Institute of Technology - CSIP (Center for Signal and Image Processing), Sept. 7, 2004, "Speech Coding at Very Low Bit Rates based on Temporal Decomposition".

- The Third Tel-Hai Conference in Computer Science: Signal Processing and Multimedia Applications, Tel-Hai, Israel, July 2007, "Review of Signal Processing Research at the Signal and Image Processing Lab (SIPL)" (**Invited** opening lecture).
- IBM Speech Technology Seminar, IBM Haifa Research Labs, Israel, July 2, 2008, "On improving the quality of small footprint concatenative text-to-speech synthesis systems" (**Invited**).
- Institute of Computer Science, Foundation for Research & Technology-Hellas (ICS-FORTH), Heraklion, Crete, Sept. 10, 2010, "Overview of Signal Processing Research at Technion's Signal and Image Processing Lab (SIPL)".
- University of Minnesota, College of Science and Engineering, Electrical and Computer Engineering Department, Sept. 8, 2011, "Text-to-Speech Synthesis in the Era of Mobile devices" (**Colloquium talk**).
- Smart Imaging Consortium Seminar, Israel Innovation Authority, July 19, 2021, "Compression of IR Video Signals at Sensor Level" (Zoom talk).

Membership in Scientific and Professional Associations

IEEE (Institute of Electrical and Electronics Engineers): Member 1971–83, Senior Member 1984–86, **Fellow** 1987–2008 **Life Fellow**, 2009–

EURASIP (European Association for Signal Processing): Member 1991-2011.

SPIE (International Society for Optical Engineering): Member 1992-2011.

Public Professional Activities

- Organizer and session chairman of the Signal Processing Session at the 10th IEEE Convention of Electrical and Electronics Engineers in Israel, Tel-Aviv, October 1977.
- Organizer of the Signal Processing Session at the 13th IEEE Convention of Electrical and Electronics Engineers in Israel, Tel-Aviv, March 1983.
- Coordinator of Technical Committee, Member of the Organizing Committee, and Chairman of the Signal Processing Session at the 14th IEEE Convention of Electrical and Electronics Engineers in Israel, Tel-Aviv, March 1985.
- Delivering an invited Opening Lecture on: "Novel Approaches to Residual Speech Coding", at the Signal Processing Session -I of the 15th IEEE Convention of Electrical and Electronics Engineers in Israel, Tel-Aviv, April 1987.
- Session Chairman of the Digital Filters and Signal Processing - II Session at the 2nd Israel Symposium on Circuits, Systems and Control, Herzlia, May 1988.
- **Organizer & Chair** of the Signal Processing sub-Conference of the 12th International Conferences on Pattern Recognition - ICPR, Jerusalem, Oct. 1994, and Chairman of the Session on "Advances in Signal Processing".
- Member of the Technical Committee and Organizer of the Sessions on Image Processing and Speech Processing of the 18th IEEE Convention of Electrical and Electronics Engineers in Israel, Tel-Aviv, March 1995.

- Member of the Technical Committee of the International Symposium on Mathematical Morphology – ISMM’96, Atlanta Georgia, USA, May 1996.
- Member of the technical Committee of the 9th Mediterranean Electrotechnical Conference, MELECON-98, Tel-Aviv, May 1998.
- **Editorial Board: Journal of Visual Communications and Image Representation:** 1999–2012
- Technion Representative to the Electronics, Computers, and Communications Sub-Committee of the Academy-Industry Forum of the Higher Education Council: 6/1999–4/2000.
- Organizer of IEEE–Israel, Signal Processing Society Chapter, and Technion–Signal and Image Processing Lab Workshop, June 2000.
- Chairman of Signal Processing sessions in the 21st and 22nd IEEE Conventions of Electrical and Electronics Engineers in Israel, Tel-Aviv, April 2000 and Dec. 2002.
- Member of the Alon Grant committee of the National High Education Council, 2002.
- Member of the International advisory committee of the IEEE Signal Processing Society Workshop on DSP in Mobile and Vehicular Systems, Nagoya, Japan, April 2003.
- Member of the International Technical Panel of the 3rd European DSP Education and Research Symposium (EDERS 2008) and Session Chair, Tel-Aviv, Israel, June, 2008.
- **Senior Editorial Board: IEEE Journal of Selected Topics In Signal Processing:** 2011–2012.
- Session Chairman, 4th International TCE Conf. - Trends in Signal and Image Processing, Technion Computer Engineering Center, Technion, May 2014.

Reviewing manuscripts for:

IEEE Trans. Speech and Audio Processing
 IEEE Trans. Audio, Speech and Language Processing
 IEEE Trans. Image Processing
 IEEE Signal Processing Letters
 Signal Processing
 Speech Communication
 Image Communication
 EURASIP Journal on Applied Signal Processing
 EURASIP Journal on Advanced Signal Processing
 J. Visual Communication and Image Representation
 International Conferences of the IEEE: ICASSP and ICIP
 IEE Proc. Vision, Image & Signal Processing
 Electronic Letters
 Optical Engineering
 ACM - Computing Surveys
 IEEE Trans. Acoustics Speech and Signal Processing
 IEEE Trans. Circuits and Systems
 IEEE Trans. Communications

Awards

- 1984 **Ray and Miriam Klein Research Award** for the “Development of an efficient algorithm for harmonic compression of speech signals in the time domain (TDHS)”. Technion.
- 1987 **Fellow IEEE** for “Contributions to the development of Time-Domain Harmonic Scaling and its application to bit-rate reduction in speech coding systems”. **Life Fellow**, 2009.
- 1997 **Elron-Elbit Chair in Electrical Engineering**.
- 2007 **International IBM Faculty Award** for “Quality of research program in speech processing”.
- 2011 **Texas Instruments Award** for “Excellent work in the field of signal processing”.
- 2011 **University of Minnesota Outstanding Achievement Award**.
- 2014 **Best Student-paper Award** for the paper: H. Benisty, D. Malah, and K. Cramer, Sequential Voice Conversion Using Grid-Based Approximation, IEEE 28th Convention of Electrical and Electronics Engineers, Eilat, Israel.
- 2020 **IEEE SPS Sustained Impact Paper Award** for the paper: “Speech Enhancement Using a Minimum Mean Square Error Short-Time Spectral Amplitude Estimator” IEEE Transactions on Acoustics, Speech, and Signal Processing, December 1984.

List of Publications

Theses

M.Sc. Thesis: “Characterization and Measurement of Noise in Linear Active Two Ports”, (1967). Supervisor: Prof. I. Kidron.

Ph.D. Thesis: “Synthesis of Linear Discrete-Time-Varying Systems”, (1971). Supervisor: Prof. B.A. Shenoi.

Papers in Professional Journals

1. D. Malah, “Cascade Decomposition of Linear-Time-Varying Difference Operators”, *Electronic Letters*, 7, No. 12, 1971, pp. 340-342.
2. D. Malah, “The Transmission Matrix of a Class of Discrete Time Systems”, *Electronic Letters*, 7, No. 21, 1971, pp. 682-683.
3. D. Malah and B.A. Shenoi, “Synthesis of Linear-Time-Varying Systems”, *Electronic Letters*, 7, No. 23, 1971, pp. 745-747.
4. D. Malah and B.A. Shenoi, “Reduction and Transformation of Linear Discrete-Time-Varying Systems”, *Intl. Journ. Control*, Vol. 16, No. 6, Dec., 1972, pp. 1127-1136.
5. D. Malah and M. Botbol, “DFT Interpolation Kernels and Error Bounds”, *Computers & Electrical Engineering Intl. Journ.*, Vol. 13, 1976, pp. 209-213.
6. D. Malah, “Time Domain Algorithms for Harmonic Bandwidth Reduction and Time-Scaling of Speech Signals”, *IEEE Trans. Acoust., Speech, Signal Processing*, Vol. ASSP-27, No. 2, April 1979, pp. 121-133. Reprinted in J.S. Lim, Editor, “Speech Enhancement”, Prentice Hall Inc., N.J., 1983, pp. 311-323.

7. T. Schwarz and D. Malah, "Hybrid Realization of an Adaptive Filter for Real-Time Noise-Canceling Applications", *Electronic Letters*, Vol. 15, No. 21, 1979, pp. 671-672.
8. D. Malah, R.E. Crochiere and R.V. Cox, "Performance of Transform and Sub-band Coding Systems Combined with Harmonic Scaling of Speech", *IEEE Trans. Acoust. Speech, Signal Processing*, Vol. ASSP-29, No. 2, April 1981, pp. 273-283. Reprinted in K.R. Rao, Editor, "Discrete Transforms and Their Applications", Van Nostrand Reinhold Co., New York, 1985, pp. 263-273.
9. E. Goldberg, R. Kurshan and D. Malah, "Design of Finite Impulse Response Digital Filters with Non-Linear Phase Response", *IEEE Trans. Acoust. Speech, Signal Processing*, Vol. ASSP-29, No. 5, Oct. 1981, pp. 1003-1010.
10. D. Malah and J.L. Flanagan, "Frequency Scaling of Speech Signals by Transform Techniques", *Bell System Technical Journal*, Vol. 60, No. 9, Nov. 1981, pp. 2107-2156.
11. T. Peli and D. Malah, "A Study of Edge Detection Algorithms", *Computer Graphics and Image Processing*, Vol. 20, Dec. 1982, pp. 1-21.
12. A. Dembo and D. Malah, "Generalization of the Window Method for FIR Digital Filter Design", *IEEE Trans. ASSP*, Vol. 31, No. 5, Oct. 1984, pp. 1081-1083.
13. Y. Ephraim and D. Malah, "Speech Enhancement Using a Minimum Mean Square Error Short-Time Spectral Amplitude Estimator", *IEEE Trans. ASSP*, Vol. 32, No. 6, Dec. 1984, pp. 1109-1121.
14. Y. Ephraim and D. Malah, "Speech Enhancement Using a Minimum Mean-Square Error Log-Spectral Amplitude Estimator", *IEEE Trans. ASSP*, Vol. 33, No. 2, April 1985, pp. 443-445.
15. D. Hertz, R.P. Kurshan, D. Malah and J.T. Peoples, "Tone Location By Cyclotomic Filters", *AT&T Technical Journal* 1985, Vol. 6, No. 6, July-Aug. 1985, pp. 1161-1179.
16. Y. Ephraim and D. Malah, "Combined Enhancement and Adaptive Transform Coding of Noisy Speech", *Proc. IEE.*, Vol. 133, Pt. F, No. 1, Feb. 1986, pp. 81-86.
17. A. Dembo and D. Malah, "WMMSE Design of Digital Filter Banks with Specified Composite Response", *IEEE Trans. ASSP*, Vol. 34, No. 6, Dec. 1986, pp. 1529-1541.
18. A. Dembo and D. Malah, "The Design of Optimal Uniform Filter Banks with Specified Composite Response". *IEEE Trans. ASSP*, Vol. 35, No. 6, June 1987, pp. 807-817.
19. A. Dembo and D. Malah, "Statistical Design of Analysis/Synthesis Systems with Quantization", *IEEE Trans. ASSP*, Vol. 36, No. 3, March 1988, pp. 328-341.
20. A. Dembo and D. Malah, "Signal Synthesis from Modified Discrete Short-Time Transform", *IEEE Trans. ASSP*, Vol. 36, No. 2, Feb. 1988, pp. 168-181.
21. A. Satt and D. Malah, "Design of Uniform DFT Filter Banks Optimized for Sub-Band Coding of Speech", *IEEE Trans. ASSP*, Vol. 37, No. 11, Nov. 1989, pp. 1672-1679.
22. Y. Ephraim, D. Malah and B.-H. Juang, "On the Application of Hidden Markov Models for Enhancing Noisy Speech", *IEEE Trans. ASSP*, Vol. 37, No. 12, Dec. 1989, pp. 1846-1856.
23. S. Farkash, D. Malah and W.A. Pearlman, "Transform Trellis Coding of Images at Low Bit Rates", *IEEE Trans. Commun.*, Vol. 38, No. 10, Oct. 1990, pp. 1871-1878.

24. R. Fabian, D. Malah, "Robust Identification of Motion and Out-of-Focus Blur Parameters from Blurred and noisy Images", *Computer Vision, Graphics, and Image Processing - CVGIP: Graphical Models and Image Processing*, Vol. 53, No. 4, July 1991, pp. 403-412.
25. T.V. Papathomas, D. Malah, "Experimentally Obtained Thresholds for a Conditional-Replenishment Image-Sequence Coder", *Journal of Visual Communication and Image Representation*, Vol. 4, No. 1, March 1993, pp. 79-91.
26. G. Sapiro, D. Malah, "Morphological Image Coding Based on a Geometric Sampling Theorem and a Modified Skeleton Representation", *Journal of Visual Communication and Image Representation*, Vol. 5, No. 1, March 1994, pp. 29-40.
27. R. Kresch and D. Malah, "Morphological Reduction of Skeleton Redundancy", *Signal Processing*, Vol. 38, No. 1, July 1994, pp. 143-151.
28. Z. Sivan and D. Malah, "Change Detection and Texture Analysis for Image Sequence Coding", *Signal Processing: Image Communications*, Vol. 6, No. 4, Aug. 1994, pp. 357-376.
29. A. Amitay and D. Malah, "Global Motion Estimation in Image Sequences of 3-D Scenes for Coding Applications", *Signal Processing: Image Communications*, Vol 6, No. 6, Feb. 1995, pp. 507-520.
30. I. Cohen, S. Raz and D. Malah, "Orthonormal Shift-Invariant Adaptive Local Trigonometric Decomposition", *Signal Processing*, Vol. 57, No. 1, 1997, pp. 43-64.
31. I. Cohen, S. Raz and D. Malah, "Orthonormal Shift-Invariant Wavelet Packet Decomposition and Representation", *Signal Processing*, Vol. 57, No. 3, 1997, pp. 251-270.
32. R. Kresch and D. Malah, "Skeleton-Based Morphological Coding of Binary Images", *IEEE Trans. Image Processing*, Vol. 7, No. 10, Oct. 1998, pp. 1387-1399.
33. I. Cohen, S. Raz, and D. Malah, "Adaptive Suppression of Wigner Interference-Terms Using Shift-Invariant Wavelet Packet Decompositions", *Signal Processing*, Vol. 73, No. 3, 1999, pp. 203-223.
34. I. Cohen, S. Raz and D. Malah, "Translation-Invariant Denoising Using the Minimum Description Length Criterion". *Signal Processing*, Vol. 75, No. 3, 1999, pp. 201-223.
35. R. Martin, D. Malah, R. V. Cox, and A. J. Accardi, "A Noise Reduction Preprocessor for Mobile Voice Communication", *EURASIP Journal of Applied Signal Processing*, No. 8, July 2004, pp. 1046-1058.
36. A. Helzer, M. Barzohar and D. Malah, "Stable Fitting of 2D Curves and 3D Surfaces by Implicit Polynomials", *IEEE Trans. on Pattern Analysis and Machine Intelligence*, Vol. 26, No. 10, October 2004, pp. 1283-1294.
37. G. Ben-David and D. Malah, "Bounds on the Performance of Vector-Quantizers under Channel Errors", *IEEE Trans. on Information Theory*, Vol. 51, No. 6, June 2005, pp. 2227-2235.
38. A. Sagi and D. Malah, "Bandwidth Extension of Telephone-Speech Aided by Data Embedding", *J. Applied Signal Processing*, Vol. 2007, Article ID 64921, 16 pages (Open Access).

39. O. Kuybeda, D. Malah and M. Barzohar, "Rank Estimation and Redundancy-Reduction of High-Dimensional Noisy Signals with Preservation of Rare Vectors", *IEEE Trans. Signal Processing*, Vol. 55, No. 12, Dec. 2007, pp. 5579-5592.
40. O. Hadas, D. Malah, and I. Cohen, "Audio Packet Loss Concealment in a Combined MDCT-MDST Domain", *IEEE Signal Processing Letters*, Vol. 14, No. 12, Dec. 2007, pp. 1032-1035
41. N. Hait and D. Malah, "Model-based Transrating of H.264 Coded Video", *IEEE Trans. Circuits and Systems for Video Technology*, Vol. 19, No. 8, Aug. 2009, pp. 1129-1142.
42. O. Kuybeda, D. Malah and M. Barzohar, "Anomaly Preserving $\ell_{2,\infty}$ -Optimal Dimensionality Reduction over a Grassmann Manifold", *IEEE Trans. Signal Processing*, Vol. 58, No. 2, Feb. 2010, pp. 544-552.
43. H. Ben-Yaacov, D. Malah, and M. Barzohar, "Recognition of 3D Objects Based on Implicit Polynomials", *IEEE Trans. Pattern Analysis and Machine Intelligence*, Vol. 32, No. 5, May 2010, pp. 954-960.
44. S. Tiomkin, D. Malah, and S. Shechtman, "Statistical Text-To-Speech Synthesis based on Segment-wise Representation with a Norm Constraint", *IEEE Trans. Audio, Speech and Language Processing*, Vol. 18, No. 5, July 2010, pp. 1077-1082.
45. A. Vichik, R. Keshet and D. Malah, "A general framework for tree-based morphology and its applications to self-dual filtering", *Image and Vision Computing* Vol. 28, No. 10, Oct. 2010, pp. 1443-1451.
46. S. Tiomkin, D. Malah, S. Shechtman, and Z. Kons, "A Hybrid Text-to-Speech System that Combines Concatenative and Statistical Synthesis Units", *IEEE Trans. Audio, Speech and Language Processing*, Vol. 19, No. 5, May 2011, pp. 1278-1288.
47. T. Shoham, D. Malah, and S. Shechtman, "Quality Preserving Compression of a Concatenative Text-to-Speech Acoustic Database", *IEEE Trans. Audio, Speech and Language Processing*, Vol. 20, No. 3, March 2012, pp-1056-1068.
48. H. Benisty, D. Malah, and K. Crammer, "Grid-based approximation for voice conversion in low resource environments", *EURASIP Journal on Audio, Speech, and Music Processing*, 14 pp. 2016-3 (open access).
49. O. Rosen, I. Cohen, and D. Malah, "FIR-Based Symmetrical Acoustic Beamformer With a Constant Beamwidth", *Signal Processing*, *Signal Processing*, Vol. 130, 2017, pp. 365-376.
50. H. Benisty, I. Katz, K. Crammer and D. Malah, Discriminative Keyword Spotting for Limited-Data Applications, *Speech Communication*, Vol. 99, 2018, pp-111.

Papers Reprinted in Books

1. D. Malah, "Time Domain Algorithms for Harmonic Bandwidth Reduction and Time-Scaling of Speech Signals", *IEEE Trans. Acoust., Speech, Signal Processing*, Vol. ASSP-27, No. 2, April 1979, pp. 121-133. Reprinted in J.S. Lim, Editor, "Speech Enhancement", Prentice Hall Inc., N.J., 1983, pp. 311-323.

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127. D. Avidar, D. Malah, M. Barzohar, "Point Cloud Registration Refinement in an Urban Environment using 2D Edge-Maps" IEEE International Conference on the Science of Electrical Engineering, ICSEE-2018, Eilat, Israel, Dec. 12-14, 2018.

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2. D. Hertz, R.P. Kurshan, and D. Malah, "Cyclotomic Tone Detector and Locator", U.S. Patent No. 4,348,735, Sept. 7, 1982.
3. D.Hertz, R.P. Kurshan, and D. Malah, "Multiple Tone Detector and Locator", U.S. Patent No. 4,361,875, Nov. 30, 1982.
4. D. Malah, "System and Method for Noise Threshold Adaptation for Voice Activity Detection in Nonstationary Noise Environments", U.S. Patent No. 5991718, Nov. 23, 1999; European Patent No. 979504A1, Feb. 16, 2000.
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3.	Technion Research Grant ¹ Development of a Digital System for Speech Compression.	050-370	1976-77
4.	Government Agency Research Grant (same topic as above)	050-370	1977-78
5.	Government Agency Research Grant Adaptive Filtering of Speech Signals.	050-386	1977-79
6.	Motorola Research Grant Time Domain Harmonic Compression of Speech Signals.	050-407	1978-79
7.	Government Agency Research Grant Video Processing	050-477	1982-84
8.	Technion Research Grant ¹ Generalized Time-Domain Harmonic Scaling.	050-479	1982
9.	Government Agency Research Grant Speech Enhancement and Coding.	050-481	1982-84
10.	Technion and Efrat - Future Technology Research Grant Noisy Speech Enhancement.	050-483	1983-85
11.	Technion Research Grant ¹ Signal Reconstruction from Modified Short-Time Fourier Transform.	050-501	1984
12.	Tadiran, Telecommunication-Division Research Grant Digital Speech Coding.	050-519	1985-87
13.	Ministry of Industry and Commerce Research Grant Image Data Compression.	050-520	1986-87
14.	EMET Fund Research Grant Digital Image Sequence Coding with Motion Compensation.	050-564	1987-88
15.	RAFAEL Research Grant Image-Sequence Coding with Compensation of Motion and Changes in Camera Parameters.	050-704	1990-91
16.	Technion Research Fund ¹ Image Coding by Morphological Techniques.	050-773	1992-1994
17.	The S. Neaman Institute Research Grant Improving the Efficiency of Image Sequence Coders for Digital Transmission of Television Signals.	2203 (\$100,000)	1992-97

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18.	Technion Research Fund ¹ and Science Ministry Fractal Representation and Coding of Images in the Discrete Wavelet Transform Domain	050-886 (\$75,000)	1995 1996-99
19.	Technion Research Fund ¹ Speech Enhancement in a Nonstationary Environment.	050-953	1997
20.	Tadiran COM. Research Grant Low Bit-Rate Speech Coding for Transmission Over HF Channels.	050-962 (\$75,000)	1997-99
21.	Rafael Research Grant Tracking Camera Motion for Image Sequence Coding.	050-958 (\$45,000)	1998-99
22.	Technion Research Fund ¹ Speech Coding at Low Bit Rates Based on a Long Term Model for Voiced Speech.	050-039	2000
23.	Technion Research Fund ¹ Very Low Bit-Rate Speech Coding.	050-129	2002-03
24.	Technion Research Fund ¹ Show-Through Cancellation in Scanned Documents.	2003703	2004
25.	STRIMM Consortium - Ministry of Industry and Trade Transrating and Transcoding of Coded Video Signals	Neaman Inst. 33014 (\$80,000)	2003-05
26.	Rafael Research Grant Hyperspectral Image Analysis.	TRDF 1004625 (\$60,000)	2004-06
27.	NEGEV Consortium - Ministry of Trade and Industry Content Insertion Into Compressed Video Streams	TRDF 2008784 (\$400,000)	2006-10
28.	Elbit-Systems Research Grant Reversed Complexity Coding of Aerial Video	TRDF 2010933 (\$24,000)	2008-09
29.	MAFAT Grant Hyperspectral Image Analysis	TRDF 2011179 (\$50,000)	2009-11
30.	Texas-Instrument Research Grant Multimedia Signal processing	TRDF 2015158 (\$100,000)	2011-15
31.	OMEK Consortium - Ministry of Economy Registration of 3D Point-Clouds	TRDF 2021574/3241 (\$300,000)	2015-18
32.	Smart Imaging Consortium - Innovation Authority Infra-Red Sensor-Level Video Signal Coding	TRDF 2028135/2030675 (\$400,000)	2019-23

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Graduate Students

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2. Reichman, A., M.Sc. (1976), "Pseudo N-Path Filters".
3. Segal, R., M.Sc. (1977), "Two Dimensional Digital Filters".
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5. Shenberg, I., M.Sc. (1977), "Decomposition and Extraction of Multiechoed Signals".
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7. Wilk, R., M.Sc. (1977), "Real-Time Speech and Data Processing by a Computer Controlled Digital Filter".
8. Segal, M., M.Sc. (1977), "Computer Aided Design of Digital Filters".
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13. Goldberg, E., M.Sc. (1979), "Design of FIR Digital Filters with Non-Linear Phase Response".
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27. Dembo, A., Ph.D. (1986), "Design of Digital FIR Filter Arrays".
28. Arad, R., M.Sc. (1986), "Scalar and Vector Quantization in Subband Coding of Speech".
29. Ofer, E., M.Sc. (1986), "Digital Coding of Voice and Data Signals Using Multi-Pulse LPC".
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