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Overview

Machine-learning focused algorithm and real-time embedded software development in signal and image processing applications, primarily for classification in mission critical applications such as:

- Medical x-ray enhancement: adaptive multi-scale and classifier-driven image enhancement
- ECG arrhythmia detection for the ICU/CCU: adaptive perceptron training for optimized patient learning and tracking, design of a robust multi-parameter system architecture, optimization of feature extraction for robustness, algorithm-oriented code instrumentation for debugging
- Cardiac electrophysiology: automated event detection in His bundle studies
- Speech recognition: multi-resolution auditory model for high-accuracy segmentation and temporal resolution, hierarchical segmentation, feature set selection, classification, perceptually based speech compression, hierarchical (local/global) dynamic programming, multi-threshold based segmentation, end-to-end system design (including analog and DSP-based front ends)
- Speech therapy: multi-scale time/frequency feature sets used to drive diversity in a multi-view, ensemble-based classifier coupled with a dynamic form of stacking using prioritized sub-classifiers for minimal consonant pair therapy with TBI and stroke patients (including therapist and patient user interfaces)
- Missile warning systems: optimization of sensor compensation, learning appropriate sensor models, exploratory and statistical analysis of sensor calibration data, system level debugging, automation of feature selection, HMM-based feature learning, robust SVM generation and tuning, calibration image classification using an ensemble of diverse classifier architectures in a multi-view, multi-layer architecture composed of SVM's with feature selection at each node
- High-speed industrial and commercial image processing: robust segmentation, feature extraction for outlier-based detection of counterfeit currency; robust extraction of image data for decoding of distorted and damaged barcodes

Algorithms developed to address specific challenges in application areas

- Neural networks and classifiers (first published descriptions of these methods in the literature):
  - Localized linear discriminant networks
    - Hybrid RBF/linear discriminant hidden units
    - This is a mixture of experts architecture, developed independently and published the same year as "Adaptive Mixtures of Local Experts" (by Jacobs, Jordan, Nowlan & Hinton)
  - Large margin / soft margin perceptron training algorithm (published prior to the original Boser, Guyon and Vapnik SVM paper, "A Training Algorithm for Optimal Margin Classifiers")
  - Unique geometric decomposition of the perceptron training algorithm with adaptive learning rates computed independently for each geometric component (foreshadowing AdaGrad)
  - Boosting for network construction (predates AdaBoost using a similar process)
  - Stacking (sequential use of rank-ordered classifiers trained on independent feature sets)
  - Multi-view classifier architecture
- Optimized adaptation to new patient ECGs using discriminant receptive fields

- Feature learning for signal analysis using HMMs in evolving feature spaces

- SVM tuning for robustness, accuracy, and cpu efficiency by removal of outlier and partially redundant support vectors through analysis of aggregated bootstrap training results
  - Approved by BAE Empower IP committee for publication

- Feature selection/aggregation over alternative search algorithms

- Multi-scale image enhancement using per-pixel, nonlinear intensity re-mapping based on statistical relationships to multiple neighborhoods over multiple scales (possibly the first multi-scale x-ray image enhancement technique developed, although not published)

- Classifier-focused enhancement (spatial focus based on classified image content)

- Mixture models for enhanced resolution in image processing

- Ensembles of diverse classifiers

- Cascade of SVM's in multi-view / multi-layer architecture:
  - Layer-by-layer training of ensembles of SVM's using a multi-view feature front end
  - Feature selection embedded at each SVM hidden unit
  - Classifier diversity designed in using cascades of SVM's with alternative kernel types
  - BAE patent application (April, 2020): "Anomaly Detection System Using Multi-Layer Support Vector Machines And Method Thereof", US Patent application number 16/862,867

- Hierarchical dynamic programming incorporating variable begin/endpoint average path cost DP in a local/global framework for incremental, dynamically optimized input to target mapping

- Robust, multi-threshold-based segmentation

- Perceptually based speech compression for speech recognition

Project Related Accomplishments

- Sole developer of the Bridgeport-Textron speech recognition system (hardware, software, and algorithms). Multi-scale signal analysis and robust segmentation coupled with a phonetic segment lattice and a hierarchical decision-making process yielded the highest accuracy on TI-20 database of any single-board, microprocessor-based system tested at that time.

- Contributions of perceptually based speech compression for template generation (prior to mp3 algorithm publication) and multi-threshold-based robust endpoint detection to the Siemens CSE-1200 speech recognizer enabled a performance improvement resulting in acceptance in a critical internal Siemens factory application.

- First to publish (ICASSP) an algorithm achieving error-free performance on the TI-20 database.

- Initiated the Siemens Corporate Research/Siemens Medical Electronics joint project for analysis of the ECG bedside monitoring arrhythmia detection algorithm in response to an FDA-ordered shutdown. The project was a success from the standpoints of debugging and development of methods for substantial reduction in QRS detection and feature extraction variance and error rates. Potential application of neural networks for classification was also clearly demonstrated.

- Identified partners in rehabilitation medicine for collaboration: application of speech recognition technology to a challenging problem in speech therapy with traumatic brain injury and stroke patients. An algorithm based on diverse sets of multi-scale features in a stacked ensemble architecture achieved enthusiastic response from both patients and therapists for its accuracy,

effectiveness, and engaging user interface.

- Conception and successful prototype development of a virtually artifact-free, locally adaptive multi-scale image enhancement algorithm applied to medical x-rays, obtaining universally positive feedback from colleagues and radiologists, including a collaborating group at Johns Hopkins. Precursor to the Siemens DiamondView x-ray image post-processing tool.

- Independently developed a gradient orientation histogram technique for use in barcode orientation estimation and discrimination from non-barcode components of package images. Complete redesign of scanning (1D) based barcode image decoding to a high-performance image processing (2D) based algorithm incorporating a fast, hierarchical search method coupled with robust barcode data tracking (for warped images) and aggregation (for partially corrupted images) in concert with a segmentation-by-classification approach (Accu-Sort Systems).

- Introduced modern classifier development techniques for counterfeit currency detection at Cummins-Allison, including the use of image databases, Matlab for algorithm prototyping and testing, and techniques such as wavelet-based feature extraction and large-margin classifiers. Developed the first image processing-based counterfeit detection algorithm and real-time, DSP-based implementation; this board carried the primary burden of counterfeit detection and insured wins against competitors, locking in the first major customers for the NextGen currency processing system. Volunteered, in response to the threat of losing European Central Bank certification for the high-end MPS series, to completely redesign a paper currency fitness measure. The new measure, using histogram-based features in conjunction with an SVM, allowed the MPS to easily pass ECB certification testing.

- Employed Gaussian mixture modeling to demonstrate the potential of significant improvement in the resolution of closely spaced sources in EOMS sensor images for the CMWS program.

- Identified the root causes of two distinct forms of high-amplitude transients during flight tests with the EDRC sensor signal compensation method – a serious problem for the customer that had eluded discovery by team members for several years. Selection of a more appropriate model for sensor dynamic range response eliminated the first form of transient; an iterative method was employed to resolve the second form of transient, allowing the EDRC project to proceed until the customer decided that the higher calibration costs had become an issue. Proceeded to define a machine learning-based method to synthesize full sets of calibration data for each sensor by leveraging existing calibration data. This method (ADRC) is now in field test with the customer.

- Developed a robust method to generate SVMs tunable for computation vs. generalization accuracy, combined with an ensemble technique to distill multi-method feature selection results. This was a complete re-work of the feature selection / SVM generation algorithm, providing a much higher level of automation, broader coverage of feature selection techniques, and the ability to minimize SVM computation load while achieving system performance goals.

- Recently completed development, testing, and deployment of a system for detection of irregularities in images of the response of sensors to calibration data. This system is an ensemble of classifier architectures using input from independent sets of diverse groups of feature extraction operators, feature selection using ROC curves acquired during bootstrapped cross validation, and layers of both linear and RBF SVMs as hidden units. This was developed due to my earlier discovery of sensor anomalies by employing a wavelet filterbank for statistical characterization of calibration image data; that investigation led to a production line shutdown (a management recognition of importance as these sensors sell for ~ $50k/unit). Multiple engineering awards have been received for discovery of the anomalies and taking on the primary role for development of new techniques in this high-visibility effort.

Systems level perspective

My work in embedded software usually involves optimization of code, CPU, and peripheral resources for compute-intensive, time-critical functions; much of the embedded code I've written has been in bare metal environments. I believe that I have exceptionally good debugging/troubleshooting skills that are supported by a systems level view extending from the lowest level front-end data acquisition through signal/image processing and finally through to the highest level of analysis of algorithm performance. With a background that includes analog and digital circuit design (mostly for data acquisition), I am not infrequently involved in board bring-up, CPU-driven hardware debugging and optimization of sensor data acquisition, including sensor calibration. I also believe that same systems level perspective gives me the potential to leverage the trade-offs that are often available over the spectrum of analog/digital/cpu hardware through software implementation and algorithm design in pursuit of the highest levels of system performance in the field.

Design experience summary

- Languages: Matlab, Python, C, C++, Assembly languages for microprocessors and DSPs (see "processors" below), S-Plus (R being the open source version), IDL, ADA, Fortran

- Processors: TMS67xx/64xx (TI) DSPs, PowerPC, 68000, PDP/LSI-11/VAX, StarCore DSP, MIPS, Microchip (PIC), TI Microcontroller, TMS9900

- Integrated development environments: Code Composer Studio (TI DSP), PyCharm, Visual Studio, Spyder, Wind River Workbench, LUxWORKS (Lucent/Agere DSP)

- Operating systems used in development: Windows, Linux, Unix, VxWorks, VMS, RSX-11, RT-11

- Hardware design: Speech signal processing, analog and digital circuit design (including low-noise circuit design and associated board layout), data acquisition, DSP & microprocessor hardware and firmware, mini- and microcomputer interfacing

- Firmware design: Driver-level code for CPU initialization, cache/memory configuration, interrupt-driven data acquisition, parallel and serial I/O, communications, Flash ram programming, etc.; on-board and peripheral hardware debugging and optimization; sensor characterization/calibration

Highlights from recent reviews

"Passionate about his work" – "a unique and valuable asset" – "highly innovative and pays close attention to details" – "digs deeply into causes and phenomena" – "work on JATAS was exceptional and has been universally praised...instrumental in the JATAS program meeting schedule and cost" – "a creative and persistent problem solver" – "strong background in discrimination and classification techniques" – "approaches his work with energy and enthusiasm and is truly enjoyable to work with" – "a great asset to the software team" – "Typically, an algorithm expert is not the strongest software developer. Marty has proven to be the exception..." – "a strong technical background and has a natural curiosity that leads him to explore multiple approaches to a problem and think outside the box. This curiosity inspires his coworkers to continue learning and thinking creatively as well." – "an extremely hard worker and will not rest until he is satisfied with his efforts." – "reformulated a technique that was determined to be too complex for implementation … successful in coming up with a less computationally intensive approach that leads to significant compensation performance improvements." – "I have never before seen such a well-documented, well-prepared explanation of an algorithm as complex as this as the one Marty put together" – "accountable, honest, and open" – "consistently cited as being a great collaborator and a pleasure to work with."

POSITIONS

Independent Algorithm Developer
Machine learning in signal and image processing applications, April 2021 - present

Having completed two capstone elements to the BAE CMWS EOMS (missile warning sensor) calibration analysis / optimization project for which I had been the prime mover / irresistible force, I decided to resign in order to define my own version of a sabbatical. This allows me to return to both long and more recently neglected projects of my own. Those projects include the design and prototyping of a concept drift / distribution shift adaptive classifier based on localized linear discriminant networks (an extension of the architecture I presented at NIPS '91), developing multi-scale and classifier-driven image enhancement for improved visualization of Covid-19 in chest x-rays using recently published datasets (an extension of the multi-scale image enhancement algorithm for medical x-rays that I developed at Siemens Corporate Research), and continuing work, begun last summer, on fetal ECG detection from abdominal electrodes during labor using wavelet based signal analysis and an adaptive online learning approach for support vector regression in prediction and cancellation of the abdominal maternal ECG. This period has also offered me the opportunity to participate in the Boston Scientific / Vanguard Health Connected Patient Challenge with a proposal for the use of a multi-view, concept drift adaptive classifier for monitoring suicidal ideation in patients in intensive rehabilitation programs. I have also just participated in the 5G Transatlantic Lab / MIT Innovation Initiative Hack the Hospital program as a member of a group addressing the problems of socialization for children in long term hospital stays. The intent of this open ended sabbatical also affords me the opportunity to take on consulting projects which align with my interests and background in machine learning in biomedical signal and image processing applications.

BAE SYSTEMS, Signal and Image Processing Lab, Nashua, NH
Senior Principal Systems Engineer, February 2011 – April 2021
Principal Systems Engineer (contractor; same functions as above), May 2009 – February 2011

Sensor signal & image processing / algorithm development for BAE CMWS system
Developed several new approaches for utilization of raw sensor data, delivering enhanced image quality for CMWS (Common Missile Warning System), which has repeatedly saved the lives of pilots, air crews, and passengers on helicopters operating in hostile environments. The first of these significantly improves compensation of sensor image data, addressing two long-standing limitations in the sensor calibration process. In-depth analysis and detailed sensor simulation exposed a previously unknown coupling between the existing image compensation technique and the method of acquiring calibration data; this led to a new compensation technique based on a more relevant model of sensor response combined with a more robust method of utilizing calibration data. Demonstrated the possibility of synthesizing the effects of a more sophisticated calibration method without requiring actual recalibration of fielded sensors installed in aircraft; proceeded to implement that solution, which is now a critical element of the latest version of this system. Proposed a solution to a related system-level issue based on a dynamic, iterative optimization of sensor data; implementation of this technique is also complete and part of the latest release. Successfully investigated the application of Gaussian mixture modeling to increase the effective resolution of sensor image data in this application. Wrote the core of the machine learning portion of a proposal to a DOD R&D lab to investigate the potential of new techniques for use in imaging-based threat warning systems. In recognition of my work in identifying anomalies in the EOMS calibration data leading to a "stop ship" order, I have received the BAE Pioneer, Swagger, Pathfinder and Impact awards. This project has now been funded by the US government customer and has expanded to an intensive effort to identify the root cause of these anomalies, characterize them from a statistical standpoint, estimate the impact on system performance, and develop an entirely new, automated screening tool for sensor quality assessment. "Multi-view, Multi-layer, Large Margin Classifier for Anomaly Detection in Calibration Images," a US Patent filing currently in preparation through BAE Systems, describes the architecture developed for automated classification of sensor calibration images at the level of performance of in house subject matter experts [1].

Algorithm optimization/real-time software implementation for the NAVAIR JATAS program
Acted as in-house consultant to review and optimize image processing algorithm and classification algorithms written in Matlab during a critical phase in this high-profile program. Responsible for implementation of these algorithms in C++ for embedded, real-time threat detection; co-development of extensive unit tests enabled flawless performance in system testing. Matlab and Visual Studio used for PC-based algorithm optimization and C++ code development, Workbench utilized for embedded C++ testing/debugging on the target PowerPC-based hardware under VxWorks.

Algorithm development for HFI component of BAE CMWS system
Delivered an optimized feature set for the hostile fire detection (HFI) component of the CMWS system, including a framework for feature selection in parallel with classifier selection and classifier parameter optimization employing state-of-the-art machine learning techniques. Developed a robust SVM based on an aggregated support vector set extracted from bootstrapped training results. "Iterative Support Vector Elimination for Robust Support Vector Machine Synthesis", a BAE Empower IP submission, describes this technique and has just been approved for defensive publication [2]. Modified (for in-house use) scikit-learn (Python open source machine learning package) for enhanced feature selection/parameter grid search functionality. Stabilized numerical problems with the scikit-learn Hidden Markov Model and extended training options to include highly variable sequence length data for an investigation of HMMs to handle noisy, highly variable sequence length data. This work led to a new method to generate boot-strapped HMM-based log-likelihood feature spaces by iteratively reclustering data using an expanding set of HMMs used as filters, each representing increasingly refined data clusters. Matlab and Python were used for algorithm prototyping and data analysis.

CUMMINS-ALLISON CORP., Bensalem, PA – Senior Software Engineer, August 2002 – February 2009

DSP-based image processing and pattern recognition for counterfeit detection
Development of Cummins' most advanced subsystem for counterfeit detection. Using data from a reflective IR-array, this is the first system in the Cummins product line to utilize image processing, feature extraction, and automated training techniques for novelty detection. This subsystem provides the majority of counterfeit detection performance in two new Cummins products that have recently received certification by the European Central Bank. Recently completed development of an enhanced version of this algorithm to take advantage of a more powerful DSP platform (TI DM643); detailed simulation of both algorithms using Matlab indicate a significant improvement in counterfeit detection performance. The new algorithm is slated for potential replacement of the current denomination recognition and fitness evaluation functions of Cummins equipment.

Matlab was utilized for evaluation of feasibility, rapid algorithm prototyping, and optimization. Real-time algorithm implementation is in C to process notes at a rate of 1200/minute. Development work includes system integration as well as hardware debugging (data acquisition, programmable logic, memory, peripherals on a TMS6711 DSP board) and optimization of DSP code. These algorithms include use of robust image segmentation, registration, multi-scale feature extraction, clustering, adaptive combination of local classification results, and an application-specific distance measure for enhancement of the discriminability between genuine and counterfeit notes. An image sensor quality measure is based on the output of an SVM using features selected from sensor calibration data using the wrapper method.

DSP-based image and signal processing for banknote measurement and quality estimation
Volunteered to investigate the potential use of IR imaging to assess banknote inkwear; this would replace a marginal function that threatened equipment certification in Europe. Successful development of the inkwear detection function was based on feature selection and a support vector machine trained to detect inkworn notes. This effort allowed our currency sortation equipment to pass certification tests by the European Central Bank. Developed a DSP-based banknote-location module using a high-resolution image sensor and providing robust estimates of location, size and orientation tolerant to note damage. Prototyped and demonstrated a real-time system to measure and classify note defects (tears, holes, missing corners, etc.) to Federal Reserve fitness specifications. Investigation of acoustic paper quality measurements using Matlab for signal analysis, resulting in a significant optimization of filtering in sensor

hardware and microcontroller post-processing.

CAIP CENTER, RUTGERS UNIVERSITY, New Brunswick, NJ
Consultant, May 2002 – March 2003

Signal processing and pattern recognition software for airport security application
Analysis, reimplementation and testing of preprocessing, feature extraction, and classification methods for detection of explosive materials using a coherent x-ray scatter system; material-specific x-ray spectra are then classified for possible alarm generation when screening baggage. Developed Matlab routines to verify methods and check for consistency of results while reimplementing C code and reproducing previous experimental results. Reconstructed methods from minimally documented code; identified problems with existing neural tree network code. Evaluated wavelets and support vector machines as potential replacements for the existing feature extraction and classification. Participated in the initial investigation of these methods for use in the detection of nuclear materials.

AGERE SYSTEMS (LUCENT spinoff), Allentown, PA – Member of Technical Staff, 2001

DSP software tools and realtime software development
Design and development of StarPro DSP code, and associated JTAG code to implement DART functionality (debugger data access in realtime). Regression test plan and test script development for the LUxWORKS debugger's access to StarPro core and system resources. Isolated debugger performance bottlenecks through the use of Rational's Quantify and custom code instrumentation. Investigated the effects of StarPro system resource utilization (multi-core use of internal buses, cache, memory, DMA) on DART channel bandwidth. Measurement of the effect of cache on performance. Study of cycle count accuracy (datasheet/model/device).

ACCU-SORT SYSTEMS, Telford, PA – Senior R&D Imaging Software Engineer, 1997–2001

Embedded real-time image processing software development
Development of new, proprietary real-time image processing and pattern recognition algorithms to improve the performance of the Accuvision product line in the location and decoding of symbologies used for high-speed package sortation. Expanded the performance envelope for narrow, fine-pitch, and damaged barcode labels; employed a hierarchical search using features optimized for barcode/text/graphics discrimination, dynamic local orientation estimates, robust data extraction, and pattern recognition techniques. Off-line algorithm development in C (SUN/Unix). Real-time software written in C for both the Mips Risc processor (VxWorks) and an embedded PC platform (Windows NT/Visual C++). Integration, testing, and debugging of software developed by outside consultants. Technical liaison to a university consulting group. Developed a tool for automated gain, focus, and image quality measurements for production use. Design of a prototype presort label for a Postal Service competition; development of associated location and decoding algorithm; installation and performance validation at the Postal Service R&D center in Virginia (USPS program did not go beyond this stage).

CYTOMETRICS, Philadelphia, PA – Member, R&D Team, 1996–1997

Medical image processing algorithm design and hardware system development
Startup company—hardware system design and associated image processing for automated blood analysis in the early product development stages of the Hemoscan. Specification, selection and system integration of dual-camera data acquisition hardware used for clinical data collection at the Hospital of the University of Pennsylvania. Evaluation of commercial software packages for use in prototyping image analysis routines. Algorithm development for estimation of hemoglobin concentration from dual camera/dual IR band images of the micro-circulation: vessel segmentation, optical density measurement and conversion to hemoglobin concentration.

SIEMENS CORPORATE RESEARCH, Princeton, NJ – Research Scientist, MTS, AMTS, 1983–1996

ECG monitoring: real-time signal processing and pattern recognition software
Algorithm design and real-time software development for the Siemens Medical Electronics (SME) intensive-care unit ECG monitor. Initiated the joint Siemens Corporate Research/SME project and served as technical liaison and project leader. Developed robust QRS event detection, sampling phase synchronization, and feature extraction to reduce beat classification error rate by > 2x and peak data variance by > 5x on the MIT database [4, 5, 6]. Identified the cause of a long-standing failure mode that generated continuous false alarms for certain patient types in ICU monitoring situations; this was accomplished using long-term recordings with offline simulation after instrumentation of the code to better observe outputs from intermediate stages of the algorithm.

Neural network classifier development
Developed a neural network architecture and training algorithm for difficult discrimination tasks [7]. This network is based on localization of the response of linear discriminants in the input feature space in order to combine the best features of radial basis and linear discriminant functions for hidden units. The network training procedure is designed to optimize decision boundaries in regions where error rates are potentially high. In a range of discrimination tasks using speech, ECG, and synthetic data, the LLDN significantly outperforms standard multi-layer perceptron (MLP) and k-nearest neighbor classifiers.

Medical image processing
Developed a vessel contrast enhancement method for medical x-ray images based on robust statistics and multi-scale image analysis. Investigation of neural network-based vessel detection for urograms utilizing a combination of anatomy and vessel shape to focus the contrast enhancement method on candidate vessels.

DSP system design: speech analysis, image acquisition and signal conditioning
Responsible for hardware and firmware development of the DSP-based front end of the Siemens CSE-1200 speech recognition system. Concept development, feasibility analysis, and preliminary design of two DSP-based subsystems for data acquisition: DSP-controlled CCD for image acquisition and preprocessing in an automotive navigation-aid system (patented [3]); DSP-controlled acquisition of low-level signals through adaptive reduction of interference prior to A/D conversion (motor failure prediction system/Siemens Industrial Automation).

Speech recognition: algorithm, software and front-end hardware development
Developed the first algorithm to reach 100% accuracy on the NIST/TI-20 database [12]. A new dynamic time-warping algorithm (APC-DTW) was defined, which minimizes average path cost to allow a range of both start and end points. Robust word-boundary estimation was employed to stabilize the word-pattern inputs to the APC-DTW algorithm. Further reduction in word-pattern variance was obtained using models of auditory perception to control nonlinear compression in pattern generation. Use of these methods in the Siemens CSE-1200 speech recognizer resulted in acceptance of the system in a factory inspection application at a critical point in the project. Real-time software development in C and 68000 assembly language for microprocessor-based algorithm implementation. Responsible for hardware development of analog and digital versions of the speech processing/spectral analysis portion of the CSE-1200. Low-noise amplifier and printed circuit board design, implementation of discrete-time rectification and filtering circuitry for a custom switched-capacitor filterbank IC, and development of hardware for CVSD-based speech compression.

An effective technique for discrimination between minimal-pair consonants was developed and implemented in a microprocessor-based speech therapy system [10, 11]. A library of feature types derived from diphone segments captures spectral and temporal patterns at multiple levels of resolution. Subsets of features are selected as discriminatory on a patient-specific basis. Robustness is achieved, given patients' highly variable articulation, by using feature subsets independently; the decision function gives more weight to subsets that produce higher-confidence classifications. The error rate of this system

on a minimal-consonant-pair database was 6.75x lower than the best reference system. Increased motivation and rate of speech production were demonstrated in clinical evaluations.

BRIDGEPORT-TEXTRON (now **BRIDGEPORT MACHINES**), Bristol, PA –
Advanced Development Engineer, 1979–1983

Development of a speech recognition system: algorithms, hardware and real-time software
Responsible for algorithm design and hardware/software development of a microprocessor-based isolated-word recognition system for use in CAD/CAM applications. Tested in 1982 using the National Bureau of Standards TI-20 database, this system demonstrated a 0.8% error rate, the best first-pass test result reported for microprocessor-based systems at that time. The proprietary algorithm utilized robust segmentation of phonetic segments to generate a lattice structure, allowing alternative segmentation at the word level. Hierarchical searches in both the segmentation and pattern-matching phases were used to bias decision making to the more reliable portions of speech data. This approach improved performance in noise, pronunciation, and speaking-rate variation.

Developed speech-processing hardware consisting of low-noise amplification, adaptive gain control, cycle-synchronous interval and amplitude measurements, a 16-channel filterbank, phonetic feature filters, log scaling, and 12-bit A/D conversion. Aspects of the time-domain response of the human peripheral auditory system were incorporated in the filterbank for better resolution of transients. Used a dual-processor configuration for transfer of off-line algorithms written in FORTRAN on a PDP 11/23 to real-time assembly language code for the Bridgeport 68000 processor board. An interactive graphics environment was developed (for a VT-100 with graphics board) in order to visualize intermediate results, trace recognition errors, and compile performance statistics. Collected an application-specific database of over 18,000 utterances from 50 speakers for use in algorithm development and testing.

FIBERPLEX ELECTRONICS, Philadelphia, PA – Electronics Engineer, 1976–1979

Video game design and development
Entrepreneurial venture in the development of commercial video games. Special-function ICs (hybrid analog/digital I2L circuitry) were supplied by Texas Instruments, as well as use of a TI 990/4 AMPL development system for the TMS9900 16-bit microprocessor. Developed a TMS9900-based game system that generated high-quality, object-oriented graphics and minimized video RAM and real-time processing requirements. A PROM-based state machine was used to execute simple graphics commands; dual graphics generators for parallel display of static and dynamic objects greatly reduced dynamic picture complexity. Also developed commercial games based on discrete analog and digital hardware. This system used basic analog computing techniques for realistic object motion simulation coupled with extensive use of PROMS for collision detection, graphics generation and state control.

OHIO STATE UNIVERSITY HOSPITALS, DIVISION OF CARDIOLOGY, Columbus, Ohio –
Graduate Research Assistant, 1974–1975

Instrumentation design for cardiac electrophysiology
Algorithm design and real-time software implementation of a multi-channel electrophysiological signal acquisition and processing system for automation of His bundle studies measurements in a cardiac catheterization laboratory [13]. A PDP 11/45 programmed in assembly language was used to process four signal channels (2 KHz sampling rate) to obtain intra- and intercardiac event relationships at heart rates of up to 300 beats per minute. Interactive processing in setup mode allowed the cardiologist to adjust measurement preferences for each patient. Amplifier and filter design for an electrically noisy environment, including design of adaptive power-line noise cancellation techniques.

EDUCATION

MSEE, 1975, OHIO STATE UNIVERSITY, Columbus, Ohio

Biomedical instrumentation and digital systems. Research assistantship awarded through the Biomedical Engineering Center. Thesis project: real-time minicomputer-based automation of cardiac catheterization (electrophysiology) studies [13].

BSEE, 1973, DREXEL UNIVERSITY, Philadelphia, PA

Communications and control systems. Senior project, Biomedical Engineering Department: minicomputer-based signal acquisition for analysis of multi-pulse defibrillator performance. Funding awarded for proposal to use a triangular waveshape to drive electromagnetic blood flow measurement.
Superior Student program. Activities: varsity wrestling, IF football, social fraternity (Theta Chi).

PUBLICATIONS & PATENTS

[1] "Anomaly Detection System Using Multi-Layer Support Vector Machines And Method Thereof", US Patent application number 16/862,867 (filed 4/30/2020; assigned to BAE Systems).

[2] "Iterative Support Vector Elimination for Robust Support Vector Machine Synthesis," BAE Systems internal report, approved for defensive publication by BAE Systems IP review committee.

[3] "Omnidirectional Visual Image Detector and Processor," US Patent No. 5,920,337, 1999;
US Patent No. 6,262,760, 2001 (both with Judd, Gorr, Perlmutter, Hancock, Novak, and Rickard).

[4] "Multi-threshold analysis for robust QRS fiducial point estimation and feature extraction," accepted for presentation at the IEEE Conference on Computers in Cardiology, 1994 (withdrawn -- unable to attend).

[5] "Robust Preprocessing of ECG Data for a Bedside Monitoring Application," Siemens Corporate Research, internal technical report, 1994.

[6] "Control of Variance in an Unsupervised Clustering Algorithm" (with Shahraray and Theivanayagam), Siemens Corporate Research, internal technical report, 1994.

[7] "A network of Localized Linear Discriminants," *Advances in Neural Information Processing Systems 4* (NIPS 91), Morgan Kaufmann, 1992.

[8] "A design for an adaptive telecommunications device for the deaf (TDD) for communication with existing acoustically coupled TDD's," poster presentation at the First Johns Hopkins National Search for Computing Applications to Assist Persons with Disabilities, 1992.

[9] "A Network of Localized Linear Discriminants," *Proceedings of the Annual International Conference of the IEEE Engineering in Medicine and Biology Society*, vol. 13, 1991.

[10] "Minimal Consonant Pair Discrimination for Speech Therapy Using Pattern Element Selection Over Time and Frequency," *First European Conference on Speech Communication and Technology*, *EUROSPEECH-1989* (with M. B. Starkey).

[11] "Speech Therapy Using Computer Based Minimal Consonant Pair Discrimination," *Proceedings of the International Conference of the IEEE Engineering in Medicine and Biology Society*, 1988 (with M. B. Starkey).

[12] "Hierarchical DP for Word Recognition," *Proceedings of the IEEE International Conference on Acoustics, Speech and Signal Processing*, 1985.

[13] "Automation of His Bundle Studies by Means of Digital Computer," 1975, The Ohio State University (MSEE thesis; also presented at the ACEMB conference, 1975, with Schaal et al.).

RELATED ACTIVITIES

- Participant in the "Global Oncology Hack-a-Thon" (Feb. 27-29, 2016) at MGH. Sponsored by MIT Hacking Medicine, Massachusetts General Hospital, the Consortium for Affordable Medical Technologies, and Global Oncology. Developed a proposal for a smartphone/intra-oral camera-based device providing image enhancement and machine learning for classification of suspected lesions during screening for oral cancer in low-resource areas of the world (initially India). The design of this system includes a patient-specific animation of predicted disease progression (based on learned transformations through disease type-specific stages) as a tool for patient education and motivation to seek treatment. Continuing to work with multi-scale image enhancement methods in parallel with an ongoing group effort to find partners for collection of a labeled dataset of images, and help in evaluating a prototype device as it is developed.

- Participant in the MGH CAMTech Gun Violence Prevention Hackathon (April 14-15, 2018). Proposed the use of machine vision / machine learning for detection of appearance of a gun in a potential shooters' possession, to be used in schools with video monitoring systems, in order to save valuable seconds or minutes prior to a shot being fired. Scene analysis is proposed for dynamic delivery of location-specific instructions to students, teachers, and aides as the situation evolves. The proposal is based on a gun detection algorithm utilizing a deep scattering network front end for image analysis combined with gun-type specific SVM's.

- Proposals to three local Medstro Challenges – the Philips Wearables Challenge, the Spaulding Rehabilitation Hospital Challenge, and the Boston Scientific / Vanguard Health Connected Patient Challenge. These were for the use of smartphones to aggregate multi-modal feature data for use in monitoring drift to suicidal ideation in populations at high risk for suicide – teenagers and those with recently acquired disabilities. It is proposed that an architecture employing multi-view feature sets and an ensemble of concept drift aware classifiers, coupled with continuous monitoring and extraction of sensor-relevant feature data from smartphone sensors including motion, speech, facial expression, keyboard interaction, text and email content, nature and type of apps used, etc., be used, with permission, for monitoring shifts in affect as well as sudden moves towards critical points in the psyche of an adolescent or person with a recently acquired disability, moving in a dangerous direction, if state relevant feature data can be acquired on an ongoing basis, and a classifier trained to define the transition from healthy to suicidal patterns of thought and behavior.

Links to publicly viewable proposals for suicidal ideation detection:

Classifier-based Detection of Suicidal Ideation Using Feature Data Aggregated From Smartphone Use

https://medstro.com/posts/7834

Concept Drift Adaptive Classifier-based Detection of Suicidal Ideation During Rehabilitation Using Feature Data Aggregated From Smartphone Use: A Call for Collaboration

https://spauldingchallenge.com/posts/9189

https://github.com/pdp1145/Smartphone-Based-Suicide-Prevention

VOLUNTEER WORK & AWARDS

- BAE Pathfinder, Pioneer and Impact awards, 2016 – 2020, for work leading to, and driving from a technical perspective, a project of significant scale to investigate EOMS sensor anomalies through data analysis, root cause identification, and system performance analysis, as well as development of tools for a fundamental enhancement to the process of automated screening of sensors prior to shipment.

- Judge for Massachusetts Science and Engineering Fair (2019 - 2021), Regeneron International Science and Engineering Fair (2021), Delaware Valley Science Fair (2001 – 2021 / intermittent), Lehigh Valley Science and Engineering Research Fair (2001 - present), Bucks County Research Science Competition (2001 - 2008), and the Pennsylvania Junior Academy of Science (2001 - 2008). DVSF mentorship program—mentor for 11th-grade student, 2014-2015 science fair period.

- Reviewer, paper submissions: *IEEE Transactions on Acoustics, Speech and Signal Processing IEEE Transactions on Neural Networks*; and the journal *Neural Computation* (while at Siemens).

- Siemens Corporate Research: Internal award for development of a joint project with Siemens Medical Electronics for applied research in ECG classification, 1993.

- Siemens Outstanding Achievement Award for contributions instrumental to the success of the Siemens CSE-1200 speech recognition system, 1985.

- American Association for Advancement of Science technology program for the disabled: designed and built a series of capacitive-touch one-hand keyboard/communication systems for a person with ALS, 1983.

- Custom design, construction and installation of remote doorbell signaling devices (FM over power lines) for deaf and hard-of-hearing users, 1976-1977.