Proposal for Mentored Undergraduate Summer Experience
Summer 2015

Principal Investigator: Larry A. Pearlstein

EMAIL:	pearlstl@tcnj.edu
Title:	Associate Professor
Tenure status:	pre-tenure
Years at TCNJ:	0.5
Department:	Electrical and Computer Engineering

Project Title: **Active Audio Cancellation of Electronically Amplified Sound**

Student collaborators: **Juliann Swift (swiftj2@tcnj.edu)**
Shubham Tandon (tandons1@tcnj.edu)

Requested funding:	$9587
Approvals:	No IACUC or IRB approvals needed
Most recent MUSE award:	None

Project and Learning Plan:

I) Intellectual Merit

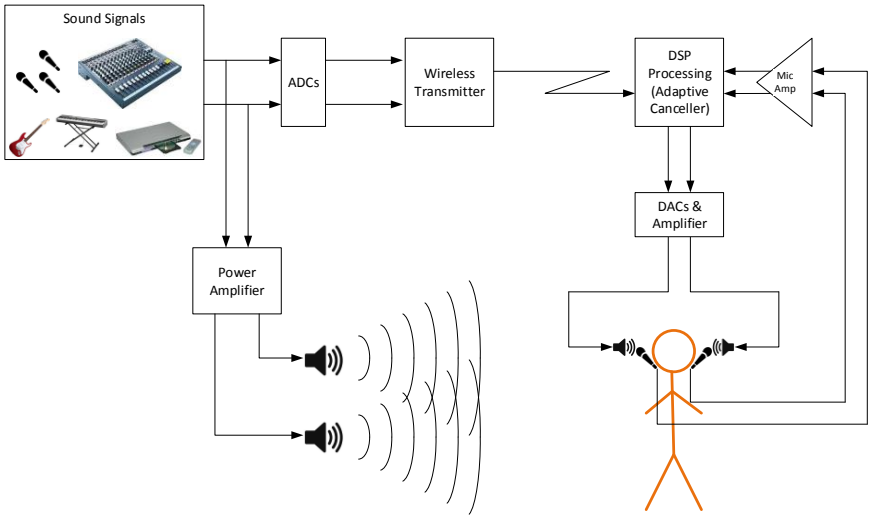
The proposed research will address the problem of selective cancellation of amplified environmental sound. An example of the scenario to be addressed is a concert venue or wedding reception where there is loud recorded (or otherwise electronically produced) music for entertainment, but where some of those in attendance desire, or need, to carry on conversation. As most would appreciate this type of scenario is not uncommon, and it is often difficult to hear normal conversational levels in the presence of loud ambient sound. The proposed research aims to apply and extend existing techniques for active noise cancellation, and to combine this with packet-switched wireless digital audio communication. The ultimate goal would be to allow people to conduct a conversation at normal speaking levels.

The basic approach to offline adaptive linear noise cancellation was developed over 40 years ago. Many improvements to address convergence rate issues and residual error have also been developed. While this approach provides the basic mathematical formulation of the problem it does not directly address the problem considered herein – namely that of live cancellation of sounds in a changing acoustical environment.

There have been efforts aimed at active cancellation of narrowband vibration, such as occurs in ductworks, or effects of engine noise. These rely on the nearly periodic nature of the undesired signal and are not suitable to solve the current problem.

Finally there are approaches based on a self-contained apparatus worn near the ears, typified described as "noise cancelling headphones". This arrangement is unsuitable to the current problem formulation as it acts to remove all sounds from the environment, including the desired sounds emanating from an intended conversation partner.

The proposed research will explore the possibility of taking advantage of faster-than-sound transmission of a signal related to the undesired sounds at the listener to produce broadband attenuation of these sounds. A sketch of how the system might operate is shown to the right.



It should be clear that successful attainment of the research goals would offer substantial benefits and may represent commercially viable technology. Furthermore, the work described here could have applications to defense, intelligence and homeland security.

We anticipate a number of challenges – including the difficulty to accurately measure the vibrations that are ultimately picked up by the human auditory system and the challenge of

sufficiently fast adaptation to changing acoustical propagation. The planned MUSE work will lay the foundation for exploring the hard problems, but is not expected to produce a fully operational system.

Specifically I plan to have Juliann work on mathematically modelling, including:

- Acquire sound signals for testing and convert to neutral format (e.g. WAV files)
- Model the entire acoustical environment and processing system via MATLAB
- Develop automation scripts in Perl, run experiments via the model, and evaluate results
- Create plots – sound power reduction vs. time for each set of experimental conditions

I plan to have Shubham work on the assembly of the hardware system, and implementation of real-time signal processing software. I will guide both students with algorithms to be used for the signal processing.

II) Role of Students and Mentor

The first week of the program will involve general training – I will meet with both students each morning and spend approximately two hours teaching the basic concepts of audio equipment, acoustics, adaptive digital filtering, modelling, scripting, the microcontroller environment and real-time programming. For the rest of each day the students will be expected to perform self-study and reinforcement of the concepts, producing results that I will review at the end of each day. I will maintain a collaborative environment, and encourage both students to become familiar with the work of the other – both as an aid to their own work, and an enhancement to the overall educational experience.

For the rest of the project duration I will meet with the students twice each week – on Monday and Friday – to plan the week and review progress, respectively. I will provide a general framework for Juliann's modeling work, including specific adaptive filtering algorithms and acoustical models. For Shubham I will create a basic system design, including hardware and software architecture. I will provide algorithms and instruction on the use of integer math to accomplish high order adaptive filters. I will expect professional-quality results from both students, including models, scripts, reports, hardware and real-time software. I will regularly review hardware and software to ensure that they meet my expectations.

III) Broader Impacts

I just joined TCNJ in September 2014, after a 25+ year career as an engineer in industry. Participating in MUSE would help to jump-start my research career at TCNJ, and would help me establish connections with our students. Being pre-tenure, a MUSE opportunity would be especially valuable in allowing me to make progress toward publishable work.

It has been widely reported that women are underrepresented in engineering. Juliann Swift is a female engineering student – giving Juliann an opportunity to engage in MUSE research would have a positive impact toward ensuring that our profession welcomes women as well as men.

APPENDIX I – Faculty Vita

Larry Pearlstein

ACADEMIC AND PROFESSIONAL EMPLOYMENT

2014-present	**The College of New Jersey** Assoc. Prof. of Elect. and Comp. Eng. Full-time	Pursued undergraduate teaching and research.
2008-2014	**Broadcom Corporation** Technical Director Full-time	Leader of the Broadcom Yardley site. Led a group doing R&D in video processing algorithms for LCD television set chips. Engaged in video technology R&D for smart phone and tablet chips. Served on the Broadcom Patent Review Committee, which evaluated disclosures for filing patents. Invited to speak at the Broadcom Technical Conference, and to present for the world-wide Technical Learning Series.
2006-2008	**Advanced Micro Devices** System-on-Chip Architect Full-time	Led in research and development of chips for LCD television sets. Invited to speak at the AMD Technical Forum.
2000-2006	**ATI Technologies** System-on-Chip Architect Full-time	Led in research and development of chips for PC-based television and set-top converter boxes.
1990-2000	**Hitachi America** Chief Researcher Full-time	Led in research of novel methods for digital video processing. Chaired the ATSC Specialists Group that developed the video coding standard for US HDTV.
1989-1990	**Computer Sciences Corporation** Lead Scientist Full-time	Developed true color graphics system for Macintosh computers that enabled display and capture of live video on the Mac desktop.
1987-1989	**BioAutomation, Inc.** Vice President of Engineering Full-time	Led in the research and development of computer vision technology for automating the interpretation of electroporetograms for DNA sequencing.
1986-1987	**University of Delaware** Assistant Prof. of Elect. Eng. Full-time	Taught courses in electrical engineering, and supervised graduate and undergraduate research.

EDUCATIONAL BACKGROUND

Ph.D. in Electrical Engineering, Princeton University, 1987
Dissertation: Adaptive Linear Filters for Processing Sinusoidal Signals; Advisor: Dr. Bede Liu
National Science Foundation Graduate Fellow

MS and MS in Electrical Engineering, Princeton University, 1984
Specialized in digital signal processing, control theory and communication

BS in Electrical Engineering, Drexel University 1982
Specialized in digital signal processing, control theory and communication

ACADEMIC OR PROFESSIONAL HONORS, PRIZES AND AWARDS

Numerous key-contributor retention bonuses and awards at Broadcom, 2008-2014
Hitachi's President's Award, 1998
National Science Foundation Graduate Fellow, 1982-1987
Graduated with First Honors from Drexel University, 1982
AMP Corporation Scholarship, 1980
William and Betty Omen Scholarship, 1977

TCNJ TEACHING RECORD

ELC 383 – Electronics II
Fall 2014, 17 enrolled

ELC 411 – Embedded Systems
Fall 2014, 39 enrolled

I redesigned the ELC 411 syllabus and selected a new textbook, in order to better align the material to current industry practices.

ACADEMIC ADVISING AND STUDENT MENTORING RECORD

As a new member of the ECE Faculty I have not yet had an opportunity to perform academic advising.

I have had experience mentoring the 8 students in my two senior project teams. I have conducted weekly meetings with my students where each student reports on the week's progress against plan, and provides a view of the plan for the upcoming week. I have even met with my teams prior to officially starting at TCNJ, and have provided extended individual guidance to team members, as appropriate.

SCHOLARLY RECORD

PUBLICATIONS

R. Selvaggi and L. Pearlstein, "Broadcom mediaDSP: A Platform for Building Programmable Multicore Video Processors," IEEE Micro, vol. 29, no. 2, pp. 30-45, March-April 2009

- Mr. Sevlvaggi and I co-architected the mediaDSP platform. We were generally responsible for different aspects of the work but we consider our contributions of equal magnitude. The work resulted in several granted patents, some where I am primary inventor, others where I am a secondary inventor. Mr. Selvaggi was listed first on the article as he initiated the process of getting corporate approval to publish.
- The IEEE Micro article was invited, based on our presentation at the well-known *Hot Chips* conference at Stanford University.
- 9 citations
- IEEE Micro has 1.812 impact factor

Y. Jia, Q.D. Le, L. Pearlstein, P. Swan, "Video Processing in HDTV Receivers for Recovery of Missing Picture Information: De-interlacing, Frame-Rate Conversion, and Super-Resolution," Information Display, vol. 23, no. 11, Nov. 2007.

- I was invited to publish my work on HDTV receivers in Information Display. I organized the team of authors listed, and each of us contributed roughly ¼ of the paper. I listed authors alphabetically.
- 2 citations

J. Boyce, L. Pearlstein, "Low-Cost All Format ATV Decoding with Improved Quality," Proceedings of the 1996 SMPTE Winter Conference, Seattle.

- I initiated much of the work covered in this conference paper. We listed authors alphabetically.
- 6 citations

J. Boyce, J. Henderson, and L. Pearlstein, An SDTV decoder with HDTV capability: an all-format ATV decoder," Proceedings of the 1995 SMPTE Fall Conference, New Orleans.

- I initiated much of the work covered in this conference paper. We listed authors alphabetically.
- 19 citations

J. Augenbraun, J. Boyce, L. Pearlstein and M. Plotnick, "A Comparative Analysis of Methods for Joint Coding of DCT Coefficients for Digital Video Compression," Proceedings of the 1992 International Workshop on HDTV, Kawasaki, Japan.

- I led the research covered in the paper, and performed much of the work myself. We listed authors alphabetically.

K. Barner and L. Pearlstein, "Two New Methods for Adaptive Pre-Equalization: Bootstrapping and Adaptive Inversion," Proceedings of the Johns Hopkins Conference on Information Sciences and Systems, 1989.

- Dr. Barner was my graduate student advisee, and carried out the work covered in this paper under my supervision. He is currently the Chair of the Department of Electrical and Computer Engineering at the University of Delaware.

P. Mack and L. Pearlstein, "Asymptotic Accuracy of an Adaptive Notch Filter with Pseudolinear Regression Approximation," Proceedings of the Johns Hopkins Conference on Information Sciences and Systems, 1989.

P. Mack and L. Pearlstein, "An Adaptive Notch Filter with Quadratic Performance at Linear Cost," Proceedings of the 22nd Annual Princeton Conference on Information Sciences and Systems, 1988.

- Dr. Mack was my graduate student advisee, and carried out the work covered in these papers under my supervision. She went on to attain a Ph.D. as my advisee. Dr. Mack is currently the Chair of the Department of Electrical and Computer Engineering at Morgan State University.

L. Pearlstein and B. Liu, "Convergence Rate of the Adaptive Line Enhancer with Tap Failures," Proceedings of the 1987 IEEE International Conference on Acoustics, Speech, and Signal Processing, Dallas, TX.

L. Pearlstein and B. Liu, "Retrieval of Sinusoidal Signals by Adaptive Notch Filtering," Proceedings of the Twenty-Third Annual Allerton Conference on Communication, Control, and Computing, Monticello, IL, October 1985.

- I conducted the research covered in these papers under the supervision of my advisor, Dr. Bede Liu.

INVITED TALKS

A Parallel Processing Architecture for the Digital Multimedia Revolution (with Richard Selvaggi), Princeton University, 2007.

The Computational Challenges of US HDTV, Princeton University, 1999.

Tutorial on MPEG Video Coding at 1995 Society of Motion Picture and Television Engineers Conference.

Tutorial on US Advanced Television for the 1995 IEEE International Symposium on Circuits and Systems.

Technical Overview of Digital HDTV for the US, University of Connecticut, 1993.

US PATENTS

Only issued patents shown, additional patents pending. Note that some patents have identical titles. This is generally due to a process where the US Patent Office has split patent applications into multiple inventions, and awarded multiple patents.

5444575	Method for recording digital data using a set of heads including a pair of co-located heads to record data at a rate lower than the full recording rate possible using the set of heads
5493456	Method and apparatus for increasing the recording time of a digital video tape recorder
5568200	Method and apparatus for improved video display of progressively refreshed coded video
5581310	Architecture for a high definition video frame memory and an accompanying data organization for use therewith and efficient access therefrom
5592299	Method and apparatus for reducing the amount of data required to represent a video frame
5614952	Digital video decoder for decoding digital high definition and/or digital standard definition television signals
5614957	Digital picture-in-picture decoder
5617565	Broadcast interactive multimedia system
5635985	Low cost joint HD/SD television decoder methods and apparatus
5646686	Methods and apparatus for reducing drift in video decoders
5668918	Method for recording digital data using a series of adjacent heads of alternating azimuths located on a headwheel to record data at a rate that is less than the full recording rate possible using the heads
5684539	Method and apparatus for processing encoded video data to reduce the amount of data used to represent a video image
5691986	Methods and apparatus for the editing and insertion of data into an encoded bitstream
5767907	Drift reduction methods and apparatus
5797001	Broadcast interactive multimedia system
5825927	Methods and apparatus for encoding video data in a manner that is well suited for decoding by regular or downconverting decoders
5828421	Implementation efficient digital picture-in-picture decoding methods and apparatus
5857181	Broadcast interactive multimedia system
5969768	Methods and apparatus for re-using decoder circuitry
5974185	Methods and apparatus for encoding video data using motion vectors for decoding by regular or downconverting decoders
6025878	Method and apparatus for decoding both high and standard definition video signals using a single video decoder

6061400	Methods and apparatus for detecting scene conditions likely to cause prediction errors in reduced resolution video decoders and for using the detected information
6061402	Methods and apparatus for efficiently decoding bi-directionally coded image data
6100932	Methods and apparatus for efficiently storing reference frame data and using the stored data to perform motion compensated predictions
6122321	Methods and apparatus for reducing the complexity of inverse quantization operations
6141059	Method and apparatus for processing previously encoded video data involving data re-encoding.
6141456	Methods and apparatus for combining downsampling and inverse discrete cosine transform operations
6148032	Methods and apparatus for reducing the cost of video decoders
6148033	Methods and apparatus for improving picture quality in reduced resolution video decoders
6167089	Reduced cost methods and apparatus for decoding bi-directionally coded image data
6175892	Registers and methods for accessing registers for use in a single instruction multiple data system
6249547	Methods and apparatus for decoding high definition and standard definition digital video images using a single decoder apparatus
6262770	Methods and apparatus for decoding high and standard definition images and for decoding digital data representing images at less than the image's full resolution
6370192	Methods and apparatus for decoding different portions of a video image at different resolutions
6385248	Methods and apparatus for processing luminance and chrominance image data
6469744	Methods and apparatus for encoding, decoding and displaying images in a manner that produces smooth motion
6539058	Methods and apparatus for reducing drift due to averaging in reduced resolution video decoders
6563876	Methods and apparatus for decoding and displaying high definition and standard definition digital video images at standard definition resolution
6594311	Methods for reduced cost insertion of video subwindows into compressed video
6668018	Methods and apparatus for representing different portions of an image at different resolutions
6829303	Methods and apparatus for decoding images using dedicated hardware circuitry and a programmable processor
7132963	Methods and apparatus for processing variable length coded data
7173970	Methods and apparatus for decoding and displaying multiple digital images in parallel
7295611	Methods and apparatus for decoding and displaying different resolution video signals
7385534	Methods and apparatus for processing variable length coded data
7434024	SIMD processor with register addressing, buffer stall and methods
7434034	SIMD processor executing min/max instructions
7555513	SIMD processor having enhanced operand storage interconnects

7573938	Methods and apparatus for decoding and displaying different resolution video signals
7743376	Method and apparatus for managing tasks in a multiprocessor system
7782938	Methods for reduced cost insertion of video subwindows into compressed video
7804430	Methods and apparatus for processing variable length coded data
7941649	SIMD processor executing min/max instructions
8126050	Methods and apparatus for decoding and displaying different resolution video signals
8253854	Image processing method and system with repetitive pattern detection
8255665	SIMD processor with register addressing, buffer stall and methods
8306122	Method and apparatus for processing image data
8331659	Method and apparatus for reduced complexity video processing via special chroma handling
8363161	Systems, methods, and apparatus for synchronization of audio and video signals
8488059	Adaptation of frame selection for frame rate conversion
8565310	Hybrid memory compression scheme for decoder bandwidth reduction
8610826	Method and apparatus for integrated motion compensated noise reduction and frame rate conversion
8773587	Adaptation of frame selection for frame rate conversion

APPENDIX II - Budget

Budget Worksheet:

Budget Group	Budget Item	Amount	Sub-total
Juliann Swift	Student stipend, Juliann Swift	2500	
	Student housing, Juliann Swift	1576	
	Subtotal - Juliann Swift		**4076**
Shubham Tandon	Student stipend, Shubham Tandon	2500	
	Student housing, Shubham Tandon	1576	
	Subtotal - Shubham Tandon		**4076**
Faculty	Faculty stipend	1000	
	Subtotal - Faculty		**1000**
Project Expenses	Microcontroller development syste	100	
	Miniature microphones	50	
	Microphone preamp	55	
	Loudspeakers and mini-speakers	80	
	Amp	50	
	Poster	100	
	Subtotal - project related expenses		**435**
	TOTAL		**9587**

Project-related Expenses Justification

- Microcontroller development system
  - This will be used to perform Analog-to-Digital conversion, Digital-to-Analog conversion and real-time adaptive filtering. Possibly a Cypress PSoC5-LP system.
- Miniature microphones
  - Used to sense the pressure waves at or near the listener's ear canal.
- Microphone preamp
  - Used in conjunction with the microphones
- Loudspeakers and Mini-speakers
  - Loudspeakers are used to create the undesired ambient sound, the mini-speakers will attempt to cancel the sound near the listener's ear.
- Amp
  - Power amplifier for loudspeakers
- Poster
  - Estimated poster costs

APPENDIX III – Past MUSE award reports

No past MUSE awards.

APPENDIX IV – Student Applications

Juliann Swift
swiftj2@tcnj.edu
*PAWS ID: 651031*Computer Engineering- Junior*32 units taken*
*Expected graduation: Spring 2016*overall GPA: 2.96*requests residency*

As an eager computer engineering student of The College of New Jersey, the Mentored Undergraduate Summer Experience is a wonderful eight week opportunity to collaborate with the experienced professors at TCNJ and gain outside knowledge along with specific skills that can later be used in my major. As a student, my main goal when graduating college is to get a job in which this summer experience can broaden my knowledge and specify my talents in hardware/software development. It would make me more valuable as a possible job candidate for employers due to the specified knowledge I would be gaining.

As a junior collaborator I would be expected to treat this opportunity as a full-time job in which I have much experience with. Since my freshman year at The College of New Jersey I have worked anywhere from 20-40 hours a week with three jobs along with starting my freshman year as a three season varsity student-athlete. I currently work for TCNJ's Dr. Katz at Linearizer Technology Inc. and Linear Photonics where I specialize in working in AutoCAD LT 2009 where I create detailed drawings of the components that make up linearizers. I also recently received a position as a software development intern at ETS (Education Testing Services) where I will be coding in java. I work as a waitress in which the past three years I have been a dedicated and hard worker along with representing The College of New Jersey as an Engineering Ambassador in the Project Engineering program. I am in my junior year at The College of New Jersey and have taken an ample amount of classes, including senior classes, which have prepared me for the research that I discussed with Dr. Pearlstein. Taking classes such as digital signal processing, accelerated computer science, and control systems have given me the background knowledge for Dr. Pearlstein's research. I am a dedicated hard worker and put all my effort into completing the tasks given at hand.

Regarding specific knowledge of Dr. Pearlstein's digital video processing research, we have discussed my help focusing on an active audio canceling unit. Taking digital signal processing has sparked my interest in how MATLAB can serve as a wonderful tool in modeling systems—fortunately this is a large portion of what my research will consist. I am eager to work on this project because I was really interested in the design project regarding filtration systems in MATLAB in my digital signal processing class and The Mentored Program would allow me to broaden my knowledge and test my skills in mastering MATLAB as a program. MUSE gives students a hands-on approach to gaining more knowledge outside the classroom which I am more than dedicated and excited to be a part of.

Name: Shubham Tandon
Email: tandons1@tcnj.edu
PAWS ID: 704022
Major: Electrical Engineering
Year in School: Sophomore
Number of completed credits: 66 credits
Expected graduation date: Spring 2017
Overall GPA: 3.374
In-Major GPA: 3.309
On campus housing is requested

Statement:

I have been at The College of New Jersey since my freshman year as an Electrical Engineering major. I have taken various classes in accordance with the core of my major, such as those involving introducing and applying the fundamentals of electrical engineering. These classes were offered by the general engineering, electrical and physics department at the college. I seek to improve on the knowledge that I have received with the opportunity to learn and research more than what is taught in classes. MUSE is an excellent method for a student like myself to apply the knowledge gained in the classroom outside the classroom. MUSE is a unique resource provided by The College of New Jersey for students to prepare themselves for the post-college life, where they could apply themselves and think outside the box. Furthermore, it is a fantastic research achievement, which would be able to help me stand out when applying for further education or a job.

I have taken various courses which focus on various topics of engineering, from logic circuits to circuit analysis. Experiences from these courses will help me to succeed in research prospects that I will take part in over the summer. After contributing to various group projects, I have attained valuable experiences, which will help me work with fellow students in this research program. The projects that I have been a part of may not apply to the specific research I will be involved, but it is surely a worthy involvement of which to be a part.

Dr. Pearlstein and I have a very good understanding between ourselves. Because he is a new faculty member, I have not yet had a class with him. Although I am planning on taking a course in which I could really use his expert set of skills. All of the ideas he put forwards to me for what our research would be are on topics that I would like to do further research in and possibly build a career on. Therefore, the research that I will do in MUSE will allow me to gain valuable experience in fields that I am looking into going into.