



BMES ERC

INDUSTRIAL ADVISORY BOARD NEWSLETTER

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A Visionary View of Artificial Vision

By Gene Frantz, Texas Instruments

Disclaimer: The views and opinions expressed in this article are those of the author and do not necessarily reflect the official policy or position of Texas Instruments

My personal relationship with the NSF Biomimetic MicroElectronic Systems (BMES) Engineering Research Center actually had its origins over a decade ago. At that time, the research team in intraocular retinal prostheses was centered at Johns Hopkins. Several of us from Texas Instruments were visiting the Baltimore area, and I received a request from one of our VPs at Texas Instruments that it might be interesting to visit this team of people who were in the early stages of research in artificial vision. It was an exciting meeting as we came away very impressed with the team and their ideas. We found out later that the team we met was likewise impressed with the fact that we were willing to visit and were interested in their research.

From the very beginning I saw that there were several issues that needed to be resolved in order to be successful in artificial vision, issues that we were also facing with our future product family at Texas Instruments. Those issues were:

- How to package integrated circuits such that the body didn't destroy them or, just as bad, isolate them to the extent of making them unusable.
- How to create ultra low powered devices that would not cause damage to the body due to the heat created.
- How to power electronic devices with energy created by the body. I call it "body heat".

My promise was to provide the BMES team with any of TI's technology that would benefit their design. I also promised to introduce them to any image processing technologist at TI that would be helpful to their success. In exchange for this collaboration, their researchers were invited to TI to report on progress, and to encourage us to learn from the research staff findings so that we could communicate the impact of their project. This seemed the best of all worlds - a perfect marriage. We had access to a world class research activity to help lead us where we needed to go next with our integrated circuit technology, and they were able to collaborate with world class technologists in integrated circuit technology.

This relationship has now lasted more than 10 years, and we are still collaborating on topics important to both the BMES and TI. I will spend the rest of this discussion on one particular collaboration of which I have been part.

That collaboration has been on the miniature camera being designed by Armand Tanguay and his team. I describe it as a camera the size of a grain of rice. It will allow the camera to be placed in the eye (intraocular) to create a better prosthetic vision system for the individual. First, let me state that I had little to do with this very impressive design effort. Where my involvement began was to ask a simple question: "Where else in the body could this camera be used?" That drove an ongoing brainstorming activity of listing other uses for the camera, both inside and outside the body. The amazing result of this conversation was a list of business opportunities for the camera with a market size estimate of as much as ten billion dollars a year. The intraocular aspect of the camera constituted about one tenth of a percent of that market opportunity.

I'll note at this point in the paper that one of my unique skills is to create a market estimate for any opportunity that does not yet exist. I have been doing this for more than 20 years with relatively good results. I do warn people that "I suspect that the forecast is off by an order of magnitude, but I just don't know which way".

(Continued Page 3)

Director's Message



Mark S. Humayun, MD, PhD

Happy New Year and welcome to year 9 of the BMES ERC. Thanks to all who were able to make last year's annual meeting at Caltech. We received favorable reviews from the NSF site visit team, and will be looking to integrate insightful advice and suggestions from them this year.

Briefly, the team was pleased with the advances made by the Cortical Testbed, as well as the recent European market approval for the retinal prosthesis manufactured by Second Sight, Inc. BMES also received high marks for high numbers of publications, invention disclosures and creation of several courses based on technologies and research related to the center's development activities.

The team was pleased with the industry program's initiative to engage the industry partners. They cited Texas Instruments' multi-year industry-sponsored program as a good example of collaborative activities. This year, we will be able to add the recent Phase-I DARPA contract awarded to Dr. Jim Weiland and Morgan Technical Ceramics for development of novel, implantable microelectronic packaging technologies. With a few more collaborative proposals still under review, we hope to add to the list this year.

In order to continue adding to these successes, we must continue to prioritize dialog between you, our industry partners, and BMES. Communication helps us understand what are the best ways to create value together. Whether this is through facilitating networking for your business, collaborating on directed research programs, or introducing you to potential new hires for your organization, communication is integral in making these activities happen.

Year 10 for BMES is quickly approaching and so our focus has been placed on solidifying the self-sufficiency strategy for the center. As we mentioned in the annual meeting, USC has prioritized an endowment campaign to help fund BMES' activities, beyond 2013. Key to this drive will be evidence of industry's commitment to the center's activities and efforts. We hope that over the next two years, you continue to provide constructive feedback to help improve the center and secure its existence for years to come.

SAVE-THE-DATE

WHAT: IAB Dinner and Meeting

WHEN: March 28-29, 2012
(Dinner: March 28;
Meeting: March 29)



WHERE: Langham Hotel
Pasadena, CA

HOW: *RSVP to rsoltero@usc.edu*

NEW INDUSTRY PARTNER ANNOUNCEMENT

**Welcome senior
partner Boston
Scientific!**

Update from the Industry Program Director



Jack Whalen, PhD

Happy New Year! 2011 was a busy year for the BMES Industry Program, focused on a variety of value creating projects. Approximately \$3Million in collaborative commercialization and product development proposals were submitted to DARPA, TATRC (DoD), and to internal USC grants. So far, BMES has been awarded one of these grants, with two still under review. We continue to look for commercialization grants and funding opportunities that match our interests.

In addition to pursuing federal funding opportunities, the industry program continues to push its effort to support students interested in industry careers. Last year, Suyashree Bhonsle a USC biomedical engineering graduate student was hired by BMES technology partner, Virginia Technologies, Inc (VA Tech). We look forward to hearing great things from both Suyashree and VA Tech, Inc., and are always looking for employment opportunities for our students.

With respect to industry membership, BMES is also excited to welcome Boston Scientific as a senior member. Welcome on board! We hope this will be the start of an exciting and productive collaborative effort.

Moving forward into 2012, the industry program remains dedicated to identifying collaborative projects and ventures that add value to you, our industry partners, and also to BMES and the USC community. One approach we are using to maintain this is using last year's IAB SWOT (Strengths, Weaknesses, Opportunities, Threats) to better focus our attention on the needs and desires of our industry partners.

This February we will be hosting our first of a series of regular BMES industry teleconferences. The goal here will be to provide brief updates on latest BMES activities, including research updates, collaborative opportunities, etc., but also to offer a venue for our industry partners to voice their input and feedback so that the industry program can improve. We hope to involve as many industry partners as possible.

The industry partners may be interested in knowing that USC has been actively searching for a Director of Corporate Alliances for the entire school of medicine. This is in following with other successful corporate alliance programs as at University of Pennsylvania. Both Dr. Weiland and myself have been participating in this search and are excited to see the caliber of candidates that are under consideration. We have been vocal in expressing the need for this director to help facilitate USC's process of entering collaborative research agreements with industry partners.

On a similar note, the Stevens Institute for Innovation (USC's technology transfer office) performed an external review of its program and services to evaluate ways to improve its activities. BMES participated in this review, citing examples of our own licensing and collaborative activities.

For 2012, the industry program will continue actively searching for ways to drive disruptive technologies towards commercialization. Please continue to reach out to us with your own challenges and needs to see if we can't work to address our challenges and create value together.

Gene Frantz, Continued from Page 1

A second aspect of this collaboration was one that should have value to the whole image processing industry. Simply put, I asked another simple question: "If I had a 16-bit data word to best describe the capability of the eye, what would be its format?" After a bit of thought (and I suspect a few theoretical discussions and some extensive simulations), the answer came back as a 16-bit floating point number with 5 bits of exponent and 11 bits of mantissa (known in the industry as half precision IEEE floating point). This combination would certainly cover the 8 to 10 orders of magnitude required to represent the full dynamic range of the human eye, as well as its 6 to 8 bits of representational precision. This "aha" moment has caused much afterthought for us with new concepts of how to advance the state of the art of image processing. I'll leave those concepts to future papers written by Armand and his research team.

During part of this time of collaboration, TI had a research contract with the BMES ERC, but that was not the driving factor for the collaboration. I say this to make a point. Our collaboration was not a contractual obligation, but instead the result of a long term relationship where trust and mutual thirst for knowledge allowed us to think beyond the research at hand.

I continue to look forward to more opportunities to spend time with the research staff involved with the BMES ERC, and to interact with them on new ideas and new uses of those ideas. I also encourage all of the readers of this paper to learn its lesson. That is, there is great joy in the process of collaboration with bright people beyond the institutional walls of your company or university.

Preparing the Next Generation of Engineers

By Joseph Coccozza, PhD, BMES Co-Director, Education and Outreach

Engineering plays a critical role in the development, prosperity and security of a nation. In order for the U.S. to remain competitive on a global scale, it is imperative that a large and well-prepared engineering workforce is maintained. According to the U.S. Bureau of Labor Statistics, employment of engineers is expected to grow by 11 percent over the 2008–18 decade. Despite this demand for engineers, there has been a steady decline in the number of U.S. high school students who plan to major in engineering in college and fewer potential engineering majors are completing rigorous college preparatory programs. Furthermore, economic, educational, and political factors have created challenges in meeting projected domestic engineering labor force demands.

The U.S. labor force will be more diverse in the near future. As a result of a higher population growth among minorities, their share of the labor force is projected to increase significantly. By 2018, it is projected that blacks will comprise 12.1 percent and Hispanics 17.6 percent of the total labor force. In California, the changes in demography are even more pronounced. Approximately 58 percent of the state's population is minorities with Hispanics forming the largest subgroup at 37 percent of the total.

Although the proportions of blacks and Hispanics in science and engineering occupations have grown over time, these groups remain largely underrepresented in engineering schools and engineering jobs in the U.S. relative to their proportions in the population. If the U.S. is to reach its projected engineering workforce target, recruitment among underrepresented groups at an early stage in their education would be constructive. The development and implementation of a rigorous yet supportive educational environment where high school students are introduced to and participate in a student-centered engineering curriculum can be a strategy to help meet the nation's long-term demand for engineers.

The BMES ERC in partnership with Bravo Medical Magnet High School established the Engineering for Health Academy (EHA). The objectives of the EHA are to increase student awareness, especially among under-represented minorities, of career opportunities in science, engineering and technology; create a small learning community that provides students with a personalized and supportive learning environment that incorporates a focused vision, rigorous standards –based curriculum, and increase science and math literacy, among students who respond to a real world “hands on” approach to instruction.

Currently in its fourth year, the EHA has 62 students participating in the program. Students enter the academy in the 10th grade and are asked to make a three year commitment to the program. They enroll in 4 core classes, each of which has a biomedical engineering focus, offers honors credit, and meets requirements for admission to the University of California and California State University systems. As seniors, EHA students participate in a research experience capstone class (RECC) that matches them with engineering research laboratories at the University of Southern California. The RECC offers students the opportunity to work as part of a team on cutting-edge research topics.

Assessment of the program indicates that EHA students are achieving proficiency in science and mathematics to a greater degree than their non-EHA counterparts at the same high school. Another key achievement is that all of the students that formed the first cohort of graduating EHA seniors have been admitted to college. Eighty-eight percent of the students have declared a STEM (Science, Technology, Engineering, Mathematics) major and, significantly, seventy-one percent have chosen to major in an engineering field.

These findings support the hypotheses that introducing high school students to biomedical engineering in a rigorous but supportive learning environment will result in students choosing to pursue STEM and engineering majors at the post-secondary level. The Engineering for Health Academy may serve as an educational model to increase the number of students, including underrepresented and female students entering the STEM workforce.



Karina Cardenas (background) was an EHA student in Dr. Jim Weiland's lab. She worked on the retinal prosthesis project. Currently, Karina is majoring in biomedical engineering at the University of California, Irvine.

“Snapshots” of the BMES Student Leadership Council



Samantha Cunningham received her Bachelor’s degree in Biomechanical Engineering from Stanford University, where she also completed a tutorial in computational neuroscience through Stanford’s Overseas Studies program at Oxford University. She received her Master’s degree in Biomedical Engineering from USC and is currently a BME Ph.D. student in Dr. James Weiland’s Bioelectric Research Lab. Her current research focuses on using functional magnetic resonance imaging (fMRI) and diffusion tensor imaging (DTI) to determine how a retinal prosthesis affects the functional organization and connectivity of the visual cortex in low vision and blind individuals. Samantha’s general research interests include interdisciplinary work that integrates imaging technologies, neuroscience, psychology, and engineering. She eventually aspires to help design sustainable medical technologies for developing countries.

Samantha is currently Co-Chair of the BMES ERC Student Leadership Council, the Community Service Chair for the Minority Engineering Graduate Association at USC, and a volunteer at the Downtown Women’s Center in Los Angeles. Outside of research, Samantha enjoys reading and writing science fiction and is an avid classical pianist, cellist, and Guzheng player. She has always had a passion for food and can often be found exploring food festivals or taking cooking classes. Samantha most enjoys combining her love of food and foreign cultures by traveling to different countries at every opportunity.



Navya S. Davuluri received her Bachelor’s degree in Bioinformatics from the University of California, Santa Cruz in 2007. After graduation, she joined a Biotechnology research team at NASA Ames Research Center working on predicting structure of proteins called chaperonin complexes. She also worked as an intern at a company called LS9, Inc., doing phylogenetic analysis and developing an internal BLAST system. Currently, Navya is a PhD student in the Department of Biomedical Engineering under the supervision of Dr. Jim Weiland.

Navya’s research is focused on the study of the neuronal response to electrical stimulation in degenerate retina using intrinsic signal imaging and electrophysiology techniques. She tries to explore the correlation between the morphological and electrophysiological changes as a degree of retina degeneration in a rodent model. She hopes to improve the resolution, electrode design and stimulus parameters of the retinal prosthesis by understanding the optical and electrophysiological response of the diseased retina to electrical stimulation.

Besides working on her thesis project, Navya is an avid reader and enjoys dancing. She has been trained in an Indian classical dance form called Kuchipudi and she likes to explore different dance forms. In addition to reading and dancing, she will begin training for the San Francisco Marathon, enjoys hiking and hopes to travel the world once she completes her studies.

Faculty in the News

- **Dr. David Hinton (USC)** was appointed Director of the Research Scholar Program by USC’s Keck School of Medicine (August 2011).
- **Dr. Mark Humayun (USC)** received the following honors:
 - Appointed University Professor by USC President C. L. Max Nikias (January 2012).
 - Named as one of the “135 Leading Ophthalmologists in America” (August 2011).
 - Made list of “2011 America’s Top Doctors” compiled by Castle Connolly Medical, LTD.
- **Dr. Ellis Meng (USC)** received the following honors:
 - Appointed WiSE (Women In Science and Engineering) Program Chair for USC’s Viterbi School of Engineering (2011).
 - Recipient of inaugural NSF Innovation Corps Award (October 2011).



BMES ERC Faculty/Staff Versus Student Soccer Match

By Karthik Murali, 2nd Year Graduate Student, PhD Program, Biomedical Engineering



Student Team

On Thursday, August 11th, the highly anticipated BMES ERC soccer game got off to a colorful start at Cromwell Field. There, BMES's Faculty & Staff team took to the field against the Student team, in what should be the first among many clashes between these soccer giants.

The Faculty & Staff's team featured a wide variety of players, ranging from experienced veterans such as James Weiland and Yannis Yortsos (Dean, USC Viterbi School of Engineering), to the youthful and energetic Matthew Lee and Joyce Tai. The Students, putting their faith in their high team chemistry, fielded their consistent starting 11, who have played alongside each other for years.

The game got off to a flying start, with the fans cheering on from the sidelines. In the first few moments, the Students threatened the opposing defense with their agility and sublime interplay. However, the cool heads on the Faculty & Staff team showed their experience by wresting control of the game. Jim Weiland's incredible vision in midfield and composure on the ball even threatened to turn the tide. It was some time before the Students, after a brilliant team effort, nicked a goal from the mean opposition defense. With the support of the crowd firmly behind them, the Students started their onslaught on the opposition goal. As half time drew close, the game was still pretty level at 2-0. During the break, the encouraging fans' gifts of water and snacks replenished both teams and they were back on the pitch to begin the second half after a few personnel changes. The highly influential substitutes for the Students made all the difference in the world as they began to amass an insurmountable lead against the Faculty & Staff. Despite all this, Faculty & Staff displayed some fine soccer, ending in spectacular shots from Yannis Yortsos, which needed the help of both the crossbar and the goalkeeper to prevent a goal. Yortsos's experience, poise and playmaking ingenuity made him a sure contender for man-of-the-match. In the end, Jack Whalen pulled one back for his team but it wasn't enough to beat the Students.



Faculty & Staff Team

The game ended with a score of 5-1. Both teams promised to come back stronger for the next matchup between the two sides. All in all, the thrilling encounter left the fans hungry for more.

90-Second Elevator Pitch Contest

The BMES ERC Industry Program sponsored an elevator pitch contest that was held on November 10, 2011 at USC's University Park Campus. The objective of the contest was for each student to deliver an "elevator pitch": a short summary used to quickly and simply define a product, service or company and its value, delivered in the time span of an elevator ride. An effective elevator pitch is designed to get the attention of a potential funder.



Contestants (l-r): Vijay Srinivasan, Artin Petrossians, Viviane Ghaderi, Samantha Cunningham, Navya Davuluri, Aminat Adebiyi, Steve Walston, Karthik Murali (not pictured: Sushmita Allam)

The contest was open to all graduate students who were funded directly by the ERC. A total of 9 PhD students majoring in biomedical, electrical and materials science engineering participated in the contest.

The goals of the competition were as follows: stimulate a culture of innovation and entrepreneurship; emphasize the value of the elevator speech; cross-pollinate student entrepreneurial experiences between centers; teach students to be concise and persuasive; stress importance of oral communication and public speaking; stimulate good performance under pressure; stimulate students to think about the bigger picture and application areas and empower students to lead.

In the months leading up to the contest, the industry program held several group and individual workshops to prepare the participants for the contest. The students were expected to pitch an innovative start-up project or company with no props except one slide. Each pitch was limited to 90 seconds in duration and addressed a BMES-related problem or opportunity.

The industry program selected the judging panel which consisted of 3 experts from academia and industry. Contestants were judged on five areas: 1) a compelling statement of problem, 2) demonstrated expertise, 3) broader impact of technology, 4) visual design of slide, and, 5) poise/style. Judges used a score sheet to rate each performance, with each of the five areas being worth a total of 4 points. The judges lauded the performances of the students and, in the end, Viviane Ghaderi, a 3rd year PhD student in electrical engineering was named the winner. Ms. Ghaderi pitched a biomimetic diabetic management system. She was awarded \$1,000, and, as 1st place winner, went on to the National Science Foundation's annual ERC meeting in Washington, DC (November 29-December 1, 2011) to compete against finalists from other participating ERC's for a prize of \$5,000.



Jack Whalen presents Viviane Ghaderi with the prize



Judges (l-r): Kathleen Allen, PhD (USC Marshall School of Business), Chris Moulding (USC Stevens Institute for Innovation), Karen Kerr, PhD (USC Stevens)

BMES Visits Singapore to Discuss MedTech Innovation

By Jack Whalen, PhD, Director of Industry Partnerships & Business Developments



Jack Whalen and Guan Yow Chen

Singapore has, for several decades, been known as a center of international trade between the East and the West. It has accomplished this through two key efforts: 1) Leveraging its nation's multilingual population (Singapore recognizes English, Malay, Chinese {Mandarin} and Tamil as official languages); and 2) leveraging its close proximity to several manufacturing and consumer nations like China, Korea, India, Australia, Malaysia and Indonesia. Marketing these attributes to global enterprises has helped Singapore emerge as a prominent venue for western companies and organizations to comfortably do business with the East.

Over the years, Singapore has had great success with this approach. This city-state, with a population of approximately 15 million inhabitants, on an island of 268 square miles, has become the 14th largest exporter and 15th largest importer of goods in the world. It is also the world's 4th leading financial center, one of the world's top three oil refining centers, and boasts the world's fifth busiest shipping port. The World Bank has praised Singapore as one of the easiest places in the world to conduct business.

A majority of this success stemmed from the emergence and growth of the microelectronics industry in the 90's. Major chip manufacturers, like Intel, set up and maintained a significant presence in Singapore since then. However, the profile of business entities setting up operations has been changing in the last decade from microelectronics to pharmaceuticals. At the turn of the millennium, the government announced an initiative to transform Singapore into one of the leading centers for pharmaceutical research and development. As of 2010, their efforts proved a large success. Through capital investment into national biotechnology research centers and incubators, as well as incentives for corporations, Singapore has been able to draw several of the key pharma manufacturers, including: Johnson & Johnson, Pfizer, Glaxo-Smith-Kline, Merck, AstraZeneca and Sanofi.

With the resounding success of its pharmaceutical initiative, Singapore is now looking for the medical technology sector to help drive its economy forward into the next decade.

I had the opportunity to meet with Dr. Guan Yow Chen, head of the "Industry Identification and Incubation Group ("I3") of the Singapore Economic Development Board (EDB). Dr. Chen is an electrical engineer who came from the semiconductor industry to help EDB to adapt its incentives and strategy to continue to bolster industrial investment into the region.

"Singapore sees the med tech industry as the next big sector, to which Singapore can make a major contribution. The last decade has seen many of the large pharmaceutical manufacturers set up operations in Singapore to take advantage of the proximity to manufacturing centers, and now Singapore hopes to generate a similar interest from the med tech center."

The nation is investing heavily in incentives and infrastructure to drive biotech and medtech into investing and operations. Biopolis, a brand new biomedical complex for research and development is an example of this investment. Phase I, completed in 2004, was a \$500 million, 2,000,000 square foot complex created to bring academic research and industry experience together to drive innovation. Phase II construction, completed in 2006, increased the complex space by over 20% at a cost of S\$70 million. And these investments are starting to yield results. Since 2007, Becton Dickenson, Siemens Medical Instruments and Medtronic have all set up R&D facilities in Singapore.

"We believe the med tech sector will be a significant driver of business for Singapore in the next decade," stated Chen. For this reason we continue to promote interactions between Singapore and US industry and academic institutions."

In addition to meeting with Dr. Chen, I had the opportunity to meet with Dr. Whye Kei (YK) Lye, head of the Nanyang Technological University's medical technology incubator, called Systemed. Dr. Lye, a US-trained electrical engineer and entrepreneur in the semiconductor industry, returned to his home country approximately one year ago to help Nanyang with translation of its internal medical discoveries towards commercialization. Dr. Lye was enthusiastic with respect to the potential opportunities, but cited significant work ahead of their small group. He will be traveling to the Los Angeles area to attend MDM West (Anaheim, CA) and to visit BMES in mid-February.

To read more about Singapore EDB and Nanyang Technological University, please visit:

<http://www.wbresearch.com/bionetworkasia/AboutOurSpeakers.aspx>

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UPCOMING EVENTS

Save-the-Date for the following:

- Medical Design & Manufacturing West Conference
February 13-16, 2012 (Anaheim, CA)
- Aspen Retinal Detachment Society Meeting
March 3-7, 2012 (Snowmass, CO)
- **BMES Industrial Advisory Board Meeting**
March 28-29, 2012 (Pasadena, CA—Langham Hotel)
Please RSVP to Rosie Soltero (rsoltero@usc.edu)
- Materials Research Society Meeting
April 9-13, 2012 (San Francisco, CA)
- American Society of Cataract & Refractive Surgery
April 20-24, 2012 (Chicago, IL)
- American for Research in Vision and Ophthalmology
May 6-10, 2012 (Fort Lauderdale, FL)
- Neural Interfaces Conference
June 18-20, 2012 (Salt Lake City, UT)
- 34th Annual International Conference of the Engineering in
Medicine and Biology Society
August 28-September 1, 2012 (San Diego, CA)

The BMES would like to acknowledge and thank all of its Industry Partners for their continued support:

Senior Partners:



Technology Partners:

Abbott Medical Optics

Harvest Precision Components



oProbe, LLC

Replenish, Inc.

