THE BRIDGE

The Magazine of IEEE-Eta Kappa Nu

Engineers' Involvement in Society

Can IEEE Save the World?

Aiding Autism with Technology

Wearable Sensors and Systems

Influencing Public Policy

June 2014 Vol. 110 / No. 2

HKN IEEE

IEEE-HKN AWARD NOMINATIONS

As an honor society, IEEE-Eta Kappa Nu has plenty of opportunities designed to promote and encourage outstanding students, educators and members.

Visit www.hkn.org/awards to view the awards programs, awards committees, list of past winners, nomination criteria and deadlines.

Outstanding Young Professional Award

Presented annually to an exceptional young professional who has demonstrated significant contributions early in his or her professional career. (Deadline: 30 April)

Vladimir Karapetoff Outstanding Technical Achievement Award

Recognizes an individual who has distinguished him or herself through an invention, development, or discovery in the field of electrical or computer technology. (Deadline: 30 April)

Outstanding Student Award

Annually identifies a senior who has proven outstanding scholastic excellence, high moral character, and exemplary service to classmates, university, community and country. (Deadline: 30 June)

Outstanding Chapter Award

Singles out chapters that have shown excellence in their activities and service at the department, university and community levels. Winners are determined by their required Annual Chapter Reports for the preceding academic year. (Deadline: 15 October)

C. Holmes MacDonald Outstanding Teaching Award

Presented annually to a dedicated young professor who has proven exceptional dedication to education and has found the balance between pressure for research and publications and enthusiasm and classroom enthusiasm and creativity. (Deadline: 30 April)

Distinguished Service Award

Presented annually to recognize those members who have devoted years of service to the society, resulting in significant benefits to all of the society's members. (Nominations accepted ongoing)

IEEE-Eta Kappa Nu (IEEE-HKN) was founded by Maurice L. Carr at the University of Illinois at Urbana-Champaign on 28 October 1904, to encourage excellence in education for the benefit of the public. IEEE-HKN fosters excellence by recognizing those students and professionals who have conferred honor upon engineering education through distinguished scholarship, activities, leadership, and exemplary character as students in electrical or computer engineering, or by their professional attainments. THE BRIDGE is the official publication of IEEE-HKN. Ideas and opinions expressed in THE BRIDGE are those of the individuals and do not necessarily represent the views of IEEE-HKN, the Board of Governors, or the magazine staff.

ISSN-0006-0809 Vol. 110 / No. 2

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The Magazine of IEEE-Eta Kappa Nu

June 2014 Features

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LETTER FROM THE PRESIDENT

JOHN A. ORR
Alpha Chapter

Dear IEEE-Eta Kappa Nu Members and Friends:

A common theme emerged at two recent events regarding the future of our profession. As current and future leaders, I think that it is important for IEEE-HKN members to give some thought to the significance of this theme.

The first event was the IEEE-HKN Student Leadership Conference at Iowa State University. I was struck by the lunchtime keynote by Gene Frantz recounting the development of Texas Instruments' "Speak & Spell" device. The Speak & Spell epitomized the beginning of a golden age of electrical and computer engineering (ECE) where the seemingly disparate disciplines of signal and information theory, digital design, embedded systems and software, solid-state device fabrication, and human speech processing came together under the umbrella of "electrical and computer engineering" to produce a useful, engaging, and low-cost device.

We have come a very long way from this toy to the smart phones of today. However, today's useful functions are less and less associated with physical devices, and hence are less associated with the ECE profession. We have done such a good job of producing information processing devices that they have become mere commodities that carry the innovative functions that are implemented in software.

Just one week after the Student Leadership Conference, I found myself at the annual meeting of the ECE Department Heads' Association where the discussion found that though traditional ECE will continue to be important, the momentum has clearly shifted from designing the platforms to designing the software for the applications and services that run on the platforms.

What should traditional electrical and computer engineers do? I think we should do what we have always done, and say "We WANT to do that and we CAN do a great job at that!" Also, as IEEE-HKN members, and using IEEE jargon, we should say that this is well within our "technical fields of interest!"

From the very beginning, ECE has been about only three things: (1) electric power; (2) information; and (3) devices and systems that process power and information. That is still true! It is just that more and more of the information processing is implemented in software. Hence, in my view, modern software and computer science principles are AT LEAST as important to an electrical or computer engineer as are circuit theory and signal theory.

My very best wishes,

Phone + 1 508-831-5273
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LETTER FROM THE EDITOR-IN-CHIEF

DR. STEVE E. WATKINS

Gamma Theta Chapter

Dear IEEE-Eta Kappa Nu Members and Friends:

This issue of THE BRIDGE magazine has a theme of "Engineers' Involvement in Society." A common definition of engineering is "Engineering is the practical application of science and math to solve problems, and it is everywhere in the world around you. From the start to the end of each day, engineering technologies improve the ways that we communicate, work, travel, stay healthy, and entertain ourselves."

Technical solutions to problems and technical innovations that improve life are illustrated in our features on autism aids and wearable devices. Beyond technical work, engineers also benefit society through their volunteer efforts and their involvement in the public policy; additional features discuss such opportunities and accomplishments.

I consider the remarkable progress in electrical and computer engineering made since Eta Kappa Nu was founded in 1904. An interesting moment in history was the Louisiana Purchase Exposition in April 1904, also known as the St. Louis World's Fair. Technology was a major element in the fair. While electricity and electrical devices were part of prior fairs, the 1904 event was notable for the extensive use of both indoor and outdoor electric lighting. What was a novelty then has become a basic infrastructure for modern life. The photograph below shows the Electrical Building with its prominent lighting.

In 2015, we will be adjusting the publication schedule for THE BRIDGE to better serve the Society. Themes for upcoming issues of THE BRIDGE magazine are:

- November 2014: "Spotlight on Student Undergraduate Research" and
- February 2015: "Smart Grid and Renewable Energy."

As always, you may send your comments on THE BRIDGE to steve.e.watkins@ieee.org.

Best regards,

Steve E. Watkins

Phone + 1 573-341-6321

Email: steve.e.watkins@ieee.org

St. Louis World's Fair Electricity Building at Night (1904).

LETTER FROM THE DIRECTOR

NANCY M. OSTIN, CAE

Dear IEEE-Eta Kappa Nu Members and Friends,

I am still all aglow from our 2014 Student Leadership Conference (led by the exceptional Nu Chapter of Iowa State) and the Electrical and Computer Engineering Department Heads Association (ECEDHA) conference (where we present the Outstanding Chapter Awards and the Outstanding Student Award). It is great to be with our students, Faculty Advisers, volunteers, department heads, and award winners. Without a doubt, this is my favorite part of my job. After these events, I am energized by your contributions, proud of IEEE-HKN, and, most importantly: enthusiastic about our future.

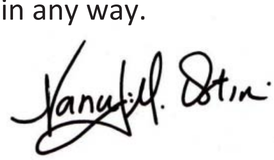
In July 2014, we plan to launch our new online community: the IEEE-HKN Virtual Campus. The Virtual Campus will provide engagement opportunities for our members, alumni, faculty and all interested communities. At its core, the Virtual Campus will include a Resource Library (including an Officers Lounge), Conference Center, Alumni Hall and Career Center. This interactive platform will grow to have forums for members to communicate with each other; a wiki to build our knowledge base; a home for alumni to reconnect, volunteer and find each other; an ongoing virtual conference; opportunities to participate in job and internship fairs; a photo gallery and more. It is our hope that this online community will provide a platform for collaboration, sharing, mentoring and strengthening our members and Chapters.

As you plan for future activities, please remember the many ways you and your Chapter can get involved, including:

- Celebrate our annual Founders Day on 28 October
- Host a regional conference for local Chapters
- Fundraise to attend the 2015 Student Leadership Conference (hosted by the Mu Chapter at the University of California, Berkeley)

When I joined the IEEE-HKN team in September 2012, we had 90 Chapters who met the criteria as "active" and therefore were eligible to vote in the Board of Governors election. In 2013, we had 156 Chapters (of 230 Chapters worldwide) who now qualified as "active." My goal for September 2014 is to have more than 200 Chapters qualified as "active" – and to keep growing!

Please stay in touch with our team at IEEE-HKN Headquarters. Don't hesitate to reach out if we can help in any way.



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Mark your Calendar!

IEEE-HKN 2015 Student Leadership Conference in Berkeley, California

Join the Mu Chapter at the IEEE-HKN 2015 Student Leadership Conference in Berkeley, California.

Are you and your Chapter members seeking opportunities for professional development, leadership training and networking with outstanding leaders of industry and academia as well as members of IEEE-HKN from around the globe? Then start planning now to attend the IEEE-HKN 2015 Student Leadership Conference, to be held 6-8 March 2015 by the Mu Chapter at the University of California, Berkeley. At the same time, the Mu Chapter will also celebrate its 100th anniversary. As always, registration for this exclusive event is free for IEEE-HKN members. More information about this event will be available in the upcoming months on the IEEE-HKN website and social media platforms.

Does Your Chapter Have the Keys to Success?

New Recognition Available in 2014

Each Chapter is encouraged to complete the requirements to be named a Key Chapter. Participation and activity in the areas identified are the best practices that successful Chapters follow. Every Chapter has the potential to earn the Key Chapter recognition! Key Chapters will receive recognition on the IEEE-HKN website and social media, celebrated by their peers, and receive a prize. The prize will be identified annually and promoted to each Chapter along with the requirements.

Mandatory requirements:

- Submit the Annual Chapter Report
- Submit the Notice of Election of Officers within one week of the election
- Submit the induction paperwork either before or within one month of their induction ceremony

Fulfill two of the following requirements:

- Send a representative to the Annual Student Leadership Conference
- Participate in one of the IEEE-HKN competitions or challenges
- Contribute workshop content to the IEEE-HKN Virtual Campus Conference Center
- Complete a Chapter activity or program to reconnect with alumni
- Host a regional meeting of Chapters (based on Chapters that are geographically accessible)

The Key Chapter recognition period will start on 1 January and complete on 31 December of the same year. The ceremony to recognize Key Chapters will be held during the Annual Student Leadership Conference of the following year. For example: 1 January, 2014 – 31 December, 2014 will be presented at the 2015 Student Leadership Conference. Questions? Contact info@hkn.org.

Can IEEE Save the World?

Or: why are engineers still considered "pseudo professionals" and how being more socially engaged can change that.

By Moshe Kam *Beta Alpha Chapter*

I. Introduction - Engineers are Not Getting Too Much Respect in My Classroom

A few years ago I taught a first-year course that was open to all undergraduate students in my university. About three quarters of my students came from the College of Engineering and most of the rest were students of Physics and Mathematics. During one of our class discussions, the conversation veered quite unexpectedly to the question of social responsibility of professionals. I asked my students which professions they consider "most socially engaged" and "most effective in addressing human and community needs." Health-related professions were on the top of everybody's list – physicians and nurses were immediately mentioned. Then came teachers, and a long list of others followed, including clergy and even lawyers and judges (though the last category elicited snickering among my students as well as some of the unavoidable lawyer jokes).

When we were done it occurred to me that in this class of mostly College of Engineering students not one student thought that engineers were socially responsible, or that they are effective in addressing societal challenges.

2. Why Are Engineers Not Considered Among the "Socially Responsible"?

The absence of engineers from the list of those "most effective in addressing human and community needs" should surprise us. After all, engineers, technologists and computer scientists are responsible for public infrastructure – including systems such as the power grid, the water supply network, the transport network, telecommunication, and the Internet. We should be deeply appreciative of the physicians and nurses who provide medical services to their communities and of the teachers who provide critically-needed education. But how about the engineers who provide the hospitals and schools with electricity? What would the face of human welfare be if we did not have effective sewer systems? If we could not store and transport food safely and at the right temperature range?

And yet one should not be totally surprised that engineers were not high on the 'humanitarian' lineup created by my students. The current public image of engineers is inconsistent with the image of protectors of humanity. We are not considered particularly benevolent or socially engaged. I sometimes hear that this gap between the public image of engineers and their self-assessment is due to misunderstandings, ignorance, or "bad public relations." If we just told the world how caring, generous and effective we are they would appreciate us much more.

I am not sure.

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To start with, when you examine how we engineers educate ourselves and how we govern ourselves, you may conclude that quite often we do not treat ourselves as responsible agents of humanity. This conclusion is hard to escape if you compare engineers to physicians and law professionals who had to address the same issues. Moreover, we engineers (and technologists and computing experts) have permitted ourselves widespread engagement in activities that are at best ambiguous and at worst inconsistent with the goal of improving human welfare.

Let me explain.

Individuals who wrote about engineering as a discipline (e.g., (Airaksinen, 1994), (Davis, 1997)) sometimes make the claim that engineering is not a "true profession" but a "quasi-profession" or a "pseudo profession." Among the arguments they make against engineering as a "true profession" is the purported lacking in engineering of "an ideal internal to its practice." It would not be possible to explain this claim in full here, but a comparison of engineers to physicians may help. While the occupation of physicians, medicine, defines health (there is no way to maintain health without medicine), the occupation of engineers, engineering and technology, does not define human welfare. Moreover, "even if engineering did define human welfare for its own practice the way medicine defines health, we could point to engineers who ignore human welfare in their work." Such engineers would not necessarily be considered impostors or charlatans among their peers, the way physicians would immediately consider those who exercised medicine formally but ignored health in their practice (Davis, 1997, p. 408). To illustrate the point further, consider the almost-universal and long-standing opposition of medical boards to the participation of physicians in capital punishment (e.g., (Council on Ethical and Judicial Affairs, AMA, 1992)). Compare this opposition to the everyday (and prevalent) participation of engineers in the development of weapons, often with very little reflection on the way that these weapons would be used, their impact, or the forces and individuals who would use them (just consider how many articles and reports boast "increased lethality" of a military system). While one could argue that under some circumstances development of weapons does contribute to human welfare and could be done ethically under such circumstances, there are numerous situations where development of weapons is as far removed as possible from contributing to human welfare.

Perhaps due to such observations some authors consider engineering to be "value-free." For example, in a very popular book called "The Undercover Economist" (Harford, 2006), Tim Harford of the Financial Times writes that engineering (like economics in his view) "will tell you how things work and what is likely to happen if you change them… What societies and their leaders do with the information is another matter."

In other words we are supposed to just do the analysis. Based on our analysis others will make the decisions and presumably they would bear the moral responsibility for the consequences…

3. Engineers vs. Physicians and Attorneys

Perhaps less dramatic, but still meaningful (and problematic) is the absence of organized *pro bono* work for the under-served in the practice of engineering. By the Latin phrase *pro bono* (which is an abbreviation of *pro bono publico*, "for the public good") we refer to "professional work undertaken voluntarily and without payment or at a reduced fee as a public service" (Wikipedia "Pro Bono", 2014). It is well known, expected and coded within the practice of medicine that every person is entitled to a certain level of medical services from an available physician irrespective of the person's income, possession of an insurance policy, or other economic matters. A person who was shot and injured would receive life-saving help in any hospital's emergency room irrespective of this person's ability to pay for these services. Other professions have also weaved pro bono work into their practice. As one example of many, law students and others who are candidates for admission to the New York State Bar are required to perform 50 hours of pro bono services (New York State Unified Court System, 2014).

While pro bono requirements are common in the practice of medicine and law, they are almost completely absent from engineering. For example, consider private engineering firms in most economies. Very few have a tradition of designating part of the engineering-design efforts expended by partners on the needs of underprivileged or under-served groups. Some engineers do volunteer, some companies encourage engineers to volunteer, but this encouragement is not an integral part of the way engineering is practiced and is far cry from what physicians and attorneys have instituted long ago as part of their common practice.

I am not pointing out this difficult issue in order to discourage engineers or engineering students from being proud participants of our community. Rather, I would like to point out that in many ways it is much harder to be an ethical and socially-responsible engineer than it is to be an ethical and socially-responsible physician or lawyer. In spite of the fact that the medical and legal professions are often engaged in resolving very complex matters under vexing circumstances, the professional and ethical boundaries of practice for physicians and attorneys are defined in a much clearer manner than the respective boundaries for engineers. To large extent this difference between these professions (medicine and law) and engineering stems from the greater difficulty in predicting the consequences and applications of engineering innovations and inventions. One need not go all the way to the design of tools of warfare to illustrate the point. Seemingly much more benign pursuits of automation, mechanization, better communication, less expensive transportation and more accurate sensing can raise very difficult ethical and societal questions. These pursuits can be planned and be used for noble and progressive ends, but can also be used for repression, aggression, warfare and perpetration of crimes. Unintended consequences of technology are not the exception but the rule. This observation was true when dynamite was invented (1860s) as well as when the Internet was invented (1960s). You could use dynamite to create roads and improve transportation, or you could use it to terrorize innocent human beings by blowing their houses up. You can use the Internet to improve communication and information exchange between people, or you can use the Internet to spy, intimidate, manipulate and steal.

4. How was Social Responsibility treated in AIEE, IRE and IEEE?

To get a better understanding of where we stand, it is helpful to examine how our organization, IEEE (established 1963 from AIEE and IRE), and its predecessors, AIEE (established 1884) and IRE (established 1912), have addressed social responsibility of engineers (the history of the IEEE Code of Ethics will have to wait for another article). I believe that the historical record would confirm that there was little official attention to social responsibility and social impact of engineering in our organization until at least the mid-1950s. Since their foundation, the AIEE and IRE put technical innovation and scientific ingenuity, as well as technical standards, at the center of their sights. The AIEE and IRE have been very successful in what they did, they have undoubtedly contributed to human welfare through their efforts, but they did so indirectly. It appears that they espoused a philosophy that is close to the “value-neutral” approach to engineering we quoted earlier from Harford: engineers develop technology; “what societies and their leaders do with the technology is another matter.”

The IRE, for example, published the IRE Transactions on Military Electronics since 1959 (it was continued as an IEEE publication until 1965), but it was not until 1972 that IEEE had a newsletter on Social Implication of Technology (it became in time the IEEE Technology and Society Magazine). Even then this newsletter was controversial, raised significant internal objections, and from time to time faced plans to have it shut down altogether (Bookman, 2006).

Efforts to address social responsibility of engineers and technology in IEEE started in 1971 when plans were made to affiliate an external organization called the Committee on Social Responsibility in Engineering (CSRE) with IEEE. The history of this effort – and of the foundation of what became in time the IEEE Society on Social Implications of Technology (SSIT) – are described in great detail in (Stephan, 2006). Given the time of its foundation, much of the focus of SSIT and its predecessor committees focused on issues that emerged from the Cold War and the Vietnam War. SSIT provided significant exposure to issues related to nuclear weapons and to safety of nuclear power, and to whistleblowing – reporting hazards in projects and systems that affect public infrastructure and consume taxpayer money. I believe it would fair to say that SSIT focused on issues that very often had explicit political implications and political overtones, and that many of its activities focused on the potentially adverse effects of technology. Most of SSIT’s focus, at least until the last decade, was on matters that unfolded in the United States (or involved United States policy). Most importantly in terms of understanding its impact, as recently as 2013 SSIT had less than 1700 members (out of 230,000 society memberships in IEEE and close to 400,000 members). SSIT (and its predecessor CSIT – the TAB Committee on Social Implications of Technology (CSIT)) had never had more than 2500 members, and they were and continue to be one of IEEE’s smallest technical societies.

5. The early 21st century – a New Wave of Interest in Social Responsibility in IEEE

During the first decade of the 21st century, volunteers in major Boards of the IEEE and members of the IEEE Board of Directors, noticed a new campaign focused on social responsibility. This was not an effort initiated by the usual organizational units of IEEE – rather, it appeared to be happening spontaneously in many places, and capture the interest of thousands of members, especially young volunteers. Increasingly these volunteers teamed up, with other volunteers and with other organizations, to provide engineering services and develop engineering prototypes for under-served populations. The multiple groups often did not ask for 'permission' from established organizational units in order to start new alliances and in many cases received the bulk of their funding from non-IEEE sources. IEEE Sections and Societies reported (and in some cases engaged-with but did not report) on scores of joint efforts with local governments, local offices of the United Nations, foundations, corporations, and charitable organizations such as Engineers without Borders (EWB). In 2008, for the first time, a plenary session on "IEEE's Humanitarian Activities" was assembled during one of the thrice-yearly IEEE Meeting Series, which brings all major IEEE boards to the same location for a week-long program of administrative meetings. The joint session on IEEE's Humanitarian Activities, chaired by the then-President of IEEE, provided therefore significant exposure for the emerging interest to engage IEEE directly and intentionally in improving human welfare. The focus was not on the adverse potential of technology but on its potential to do good and improve the human condition. Attendees of the Meeting Series could not miss the signal.

The growing interest in socially-responsible engagement resulted in several flavors of activities, and, as often is the case in IEEE, these have emerged in different corners of the organization, in different organizational units and geographical areas, at different paces and styles, and with financial support from many sources and budgets. At a later stage (starting 2011) some of these activities were coordinated by an IEEE Board-of-Directors level ad hoc committee on humanitarian activities, but many activities continued to be administered in a decentralized manner by various organizational units.

IEEE's new-style "social responsibility" activities, sometimes labeled "humanitarian activities" can be categorized as follows:

a. Local activism

Groups of volunteers teamed up with other volunteers and other organizations to address local needs in under-developed or under-served areas. Hundreds of IEEE volunteer groups are engaged in this way – some of them have organized recently as Special Interest Groups on Humanitarian Technology (SIGHTs) (IEEE SIGHT, 2014). Many chapters of IEEE-Eta Kappa Nu have been in the habit of organizing such activities locally for decades.

For an example of this kind of local effort, see the collaboration between the IEEE Foundation, the University of Colorado at Boulder and other organizations on Vocational Training for Haiti on Green Energy (University of Colorado Boulder, 2014). A SIGHT effort in the IEEE Madras Section is described in the caption to the right. (IEEE Madras Section, 2013).

Some of IEEE's activities at the local level were organized and reported-on on the joint IEEE-ASME web portal www.engineeringforchange.org.

IEEE Madras Section SIGHT along with their NGO partner Solarillion Foundation took the initiative to spread humanitarian technology among students by conducting a Solar Lamp Workshop followed by Solar Lamp Design Contest at Chennai city level in 2013 and Pan India Level in 2014. The goal was to share renewable energy technologies with students and kindle their interest in developing renewable energy projects.
Photo Credit: IEEE Madras Section SIGHT

b. Service Learning in universities and high schools

Service Learning activities are currently organized in IEEE as an extension of programs developed at Purdue University under the titles EPICS (Engineering Projects in Community Service) and EPICS-HIGH (the "HIGH" is for high schools that are part of the program). IEEE in EPICS (IEEE EPICS, 2014) has by now mobilized more than 60 project teams around the world. The initiative organizes university and high-school student teams to work collaboratively on engineering-related projects with non-governmental organizations (NGOs) and the NGOs' target audiences. The purpose is to develop and sustain community-focused projects in all geographical locations where IEEE has significant presence, and to empower student branches and other members and volunteers to work with engineering/computing students and with high school students for the welfare of the public at their locales. Examples of concluded EPICS in IEEE projects are available at (Ampofo-Anti, 2009) and

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(Log'el Project, 2011). Recent projects were completed in Belgium, Mexico, South Africa, Uganda, Uruguay, The United States (New Hampshire, New York, Pennsylvania) and Zimbabwe.

c. Development of engineering prototypes to meet societal needs

The objective of prototype-development efforts is to harness the know-how of IEEE members to develop technological solutions – prototypes for devices and algorithms. These would be available for commercialization by other organizations at a later stage. The focus is on economical, scalable and sustainable solutions that would be applicable in multiple environments and would be developed in cooperation with experts who understand local needs of under-served communities worldwide.

An example of this line of efforts is the *IEEE Humanitarian Technological Challenge* (HTC on IEEE.tv, 2010) which was conducted with the UN Foundation and Vodafone.

d. Advice and consultation teams to governmental bodies in developing countries

IEEE volunteers participate in groups and committees that assist governmental bodies in areas where IEEE members possess expert knowledge. The objective is to provide consultation and advice on technical development and education.

An example of this line of activities is the efforts of the IEEE Committee on Earth Observations (ICEO, 2014).

In 2009, the Philadelphia Section piloted an EPICS Project in partnership with the Philadelphia Clean Air Council and Science Leadership Academy, a local high-school to develop an air quality sensor network for monitoring residential areas in South Philadelphia, PA. As part of the project, Drexel University senior design team students deployed an air quality sensor network. Image Credit: Drexel University

e. Participation in high-level policy-making summits with other organizations

IEEE initiates and sustains close relationships with several international organizations active in promoting development worldwide. Through these relationships IEEE provides expert advice on policy development, and mobilizes volunteers to address emerging needs.

An example of this activity is IEEE's recent cooperation agreement with UNESCO on education in Africa (UNESCO, 2012).

f. Development of conferences and publications focused on socially-impactful activities

IEEE is widely known for its active conference program and its significant role as publisher in engineering, technology and computing. As part of this activity, IEEE organizes conferences which address directly or indirectly issues related to responsible development, engineering in developing countries, sustainability, humanitarian activities, and related policies.

Among these many conferences are the IEEE International Conference on Renewable Energies for Developing Countries (IEEE REDEC, 2012), the International Conference on e-Commerce in Developing Countries (IEEE e-Commerce, 2013), the IEEE Global Humanitarian Technology Conference (IEEE GHTC, 2014), and the IEEE Rural Electric Power Conference (IEEE REPC, 2014).

g. Fund-raising for disaster relief

From time to time IEEE engaged in fund raising for the explicit purpose of helping members and others in areas stricken by natural disasters. Such campaigns were conducted among IEEE members in 2010 (with matching 1:1 of member donations by the IEEE Board of Directors) for disaster relief in Haiti and in Pakistan.

h. Awards and recognition

IEEE recognizes members and other professionals for activities that exhibited positive impact on human welfare. These appreciations are part of the IEEE awards program which includes medals, technical field awards and other recognitions. Among the awards specifically designated to socially-impactful activities are the IEEE Rural Electrification Excellence Award (IEEE REPC Award, 2014) and the IEEE Presidents' Change the World Competition (IEEE Presidential Competition , 2014).

6. So… can IEEE save the World? Can you save the world?

There can be no doubt that new technology announced in IEEE's journals and presented through IEEE conferences has made a positive difference in the real world. Many of the tools and technologies that are in wide use today were introduced and presented for the first time in IEEE events and publications. All indications are that this trend will continue. Important technological breakthroughs have been and will be announced and assisted (and in some cases facilitated) by IEEE activities. Conferences and publications would continue to introduce technology and discuss its technical implications. Some conferences and publications will be devoted specifically to societal implications and to social engagement and responsibility.

It is not always easy to discern, however, when technical developments reported in IEEE publications and conferences are motivated by concern for human welfare and by the desire for positive social impact. There often are other powerful motivations such as economic gain, efficiency, customer needs, scientific curiosity, and general intellectual interest. Quite often there are several motivations at play simultaneously, and sometimes the real incentive is not clear even to the researcher, developer or author who announces a new finding.

Rather than addressing the whole spectrum of technology in IEEE, let us then ask a narrower question. Would the "new wave" of activities in IEEE – the collection of projects and approaches that were developed recently under the social responsibility banner (see Section 5) – be able to make a real social impact?

My personal view is that only some would. I believe that our most important activities at present are in the areas of service learning (EPICS in IEEE) and local activism (most importantly the SIGHTs). The reason I am enthusiastic about these approaches (and quite frankly much less excited about most of the rest of the list) is that service learning and local activities in the community have a direct long-term impact on us – the IEEE engineering, computing and technology practitioners and students who engage in these efforts. I am very hopeful about the potential to make an internal change in our culture and our practices. I am less hopeful about the potential of IEEE to effectuate a concerted difference when it comes to the big global challenges – building power, water and communication infrastructure where such infrastructure is scarce of non-functioning at present; improving education, especially technical education, where currently it is badly lacking; facilitate provision of healthcare in under-served areas. Even with 400,000 members, these challenges appear too large for IEEE, too intertwined with other political and social factors, and too costly and human-resource intensive. I believe we will achieve much more if we actually lower our sights.

There is one group we can affect directly, within our means and within our budget. Through programs like EPICS in IEEE and the special interest groups on humanitarian technology (SIGHTs) we have an opportunity to influence our own community – engineers, technologists, computing experts. If we focus on this direction we may be able to transform ourselves in time from the ambiguous and hardly desired state of being 'quasi-professionals' or 'pseudo-professionals' into true professionals. We can then develop a different contract with society, one that transcends "value-free" development of "agnostic technology." Such contract would make engagement with our local communities an integral part of the education of students in engineering, technology and computing. It would establish pro bono work of engineers in their community as an essential ingredient of engineering education and practice.

Among many other changes that EPICS in IEEE and the SIGHTs can introduce in engineering education is that the widely practiced last-year design project (that almost all students toward the first degree in engineering, technology and computing must complete) would no longer be performed just inside the academic laboratory. Rather, the last-year design project would be performed routinely by university students in the community, for the benefit of the community, and with real clients from the public as beneficiaries. In time this self-education of the engineering profession may make us much more tuned to the societal challenges that engineers can help tackle, and more effective in solving them.

Focusing on this approach, we may want to put IEEE's energy and (limited) resources into significant scaling of the EPICS in IEEE program (IEEE EPICS, 2014) and of our SIGHT efforts (IEEE SIGHT, 2014). These are activities that BRIDGE readers, as well as IEEE Student Branches and IEEE-Eta Kappa Nu Chapters can initiate locally, and manage autonomously with little overhead or administrative procedures. If we manage to increase the number of IEEE EPICS projects from a few scores to a few hundreds (then perhaps to a few thousands) every year; if instead of two dozen SIGHTs we would support, say, two hundred of them worldwide, we stand a chance to make a real difference – first to the engineering profession, and second, most importantly, to the society that we are bound to serve.

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IEEE-HKN PRESENTS AWARDS

Outstanding Student and Chapter Awards Presented

IEEE-HKN recently announced Tammy Chang of the Iota Gamma IEEE-HKN Chapter at UCLA as the recipient of the 2013 Alton B. Zerby and Carl T. Koerner Outstanding Student Award.

Outstanding Student Award recipient Tammy Chang with IEEE-HKN President John Orr.

The award recognizes outstanding scholastic excellence and high moral character, coupled with demonstrated exemplary service to classmates, university, community, and country.

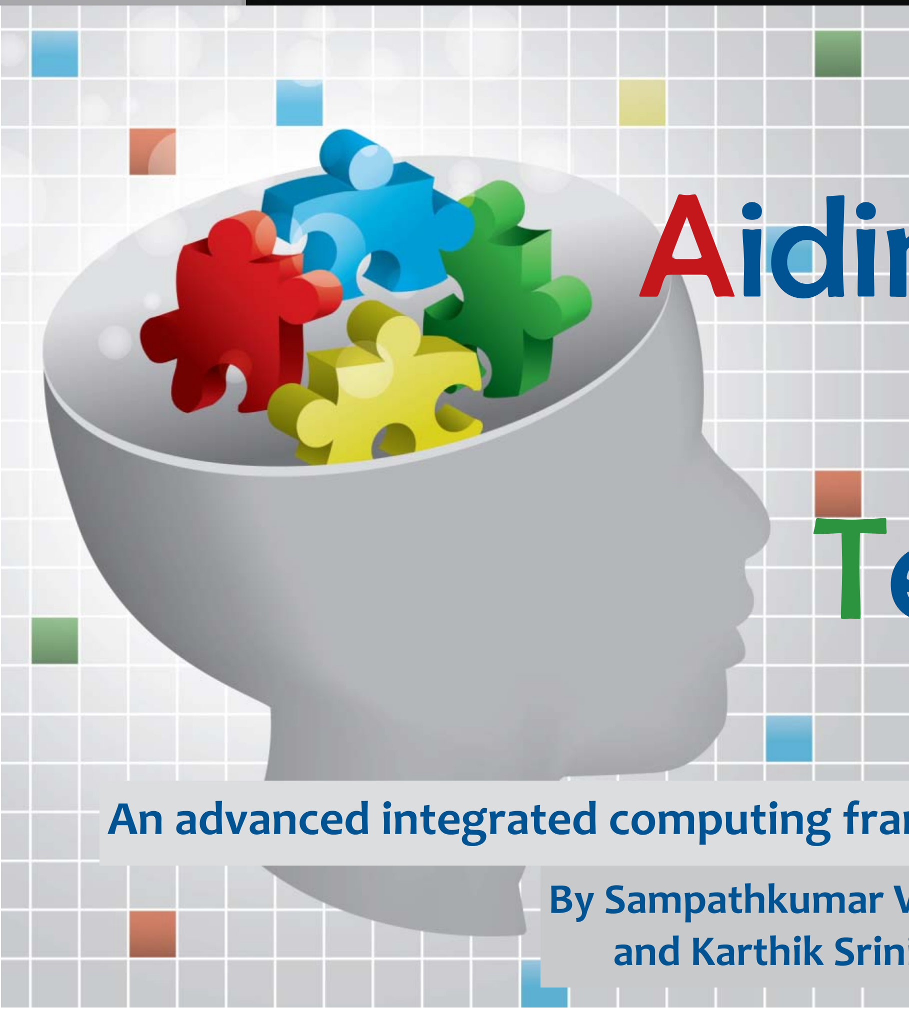
Chang graduated from UCLA with a B.S. in electrical engineering with a 3.92 GPA, ranking her sixth out of 170 students in the major. While at UCLA, she led the engineering mentorship program and served as the mentorship chair for the Iota Gamma Chapter. She is now enrolled in the electrical engineering graduate program at Stanford.

The winners of the Outstanding Chapter Award are as follows:

Alpha	(University of Illinois Urbana-Champaign)	Iota Gamma	(University of California, Los Angeles)
Beta	(Purdue University)	Kapp Psi	(University of California, San Diego)
Beta Epsilon	(University of Michigan)	Lambda Alpha	(University of West Florida)
Beta Kappa	(Kansas State University)	Lambda Eta	(Bharati Vidyapeeth's College of Engineering)
Beta Mu	(Georgia Institute of Technology)		
Beta Theta	(Massachusetts Institute of Technology)	Lambda Nu	(University of Scranton)
Delta Omega	(University of Hawaii at Manoa)	Mu	(University of California, Berkeley)
Epsilon Beta	(Arizona State University)	Nu	(Iowa State University)
Epsilon Omicron	(University of Delaware)	Psi	(University of Texas at Austin)
Gamma Mu	(Texas A&M University)	Rho	(University of Colorado Boulder)
Gamma Rho	(South Dakota State University)	Sigma	(Carnegie Mellon University)
Gamma Theta	(Missouri University of Science and Technology)	Zeta Beta	(Texas A&M-Kingsville)

The purpose of the Outstanding Chapter Award is to recognize excellence in Chapters for their activities. The award is based on the content and description of Chapter activities that are contained in the Annual Chapter Report. All awards were presented at the annual Electrical and Computer Engineering Department Heads Association (ECEDHA) conference in Napa, California, in March. Congratulations to all winners!

Representatives from the Outstanding Chapter Award with Steve Goodnick, chair of IEEE-HKN Outstanding Chapter Award Committee (right).



Aiding Autism Through Technology

An advanced integrated computing framework to explore Autism...

By Sampathkumar Veeraraghavan *Epsilon Delta Chapter*
and Karthik Srinivasan

Abstract

Social and emotional ties are an important anchor in life and hence a lack of these is a major hurdle in achieving one's dreams and goals. Autism is a social development disorder that is marked by a distinct lack of social and language skills. It is a disorder rather than an organic disease and hence is difficult to diagnose without a high index of uncertainty. Prevalence rates for Autism in various societies range from 1 in 88 to 1 in 250 [1, 2]. Autism is a socially crippling disorder and can be a huge strain on families caring for these children. The Indian scenario with regard to Autism is still in its nascent stage. There is very limited resource and infrastructure available for these children with special needs. Most Autistic children attend special care schools that provide services for children with Cerebral Palsy or Down syndrome. Hence there arises a need for developing technological aid designed to help diagnosis and increase parent participation for Autistic children. This led to the development of a Knowledge-based Screener (KBS) and an intelligent trainer system that can detect the critical symptoms of developmental disorders in a comprehensive and complete manner. Social developmental disorders comprise a wide spectrum. Pervasive developmental and similar disorders constitute this spectrum. This knowledge-based system we have developed will help to detect the presence of these disorders and support home-based intervention. The main goal of our research is to develop technological aid, which will help Autistic individuals to be identified earlier and initiate early intervention for the management of autism.

I. Introduction

Engineers through their technological innovations change the way the world interacts, work, and lives. They play an important role in bringing positive changes in the lives of people from under-represented segments of society across the globe. While the technology evolves rapidly, there is a pressing need to develop solutions that cater to the need of addressing the most pressing global humanitarian challenges. As the medical field, science and technology are improving day-by-day, complex medical disorders possess a challenge to the human community. The Autism Spectrum Disorder is one such challenge faced globally by the researchers and technologists. Autism is a "Social Developmental Disorder" characterized by marked defects in social interaction and language; this disorder may also be associated with impaired cognitive functions or other medical disorders like Epilepsy, Attention Deficit Hyperactive

Disorder (ADHD). Many cases of Autism especially high functioning Autism like Asperger Syndrome go unnoticed in the society [3, 4, 5, 6, 7]. Awareness about Autism in the Indian setting is also limited and hence parents and even some medical professionals do not consider Autism in a child with features of social developmental disorders. Autistic children benefit from early detection and treatment. But in India, early intervention is still difficult. It can take as long as two years for parents to find a doctor able to diagnose the severity of the disorder and recommend treatment. By then, they have often run out of money and patience. Treatment in rural areas is further hindered by superstitions, a plethora of regional languages, and poverty. To overcome this problem, we have devised an automated computing-based screening system for early identification of children with autism. This screener helps to identify and devise early intervention programs for autistic children.

II. Framework

The framework devised in our research extends the application of large-scale computing systems and embeds advanced computing techniques such as expert systems, data mining, advanced software technologies and complex systems engineering approach to facilitate Autism detection and management. As shown in Figure 1, the framework is comprised of three components: a multi-layered knowledge based screener, an intelligent gaming system and a data mining-based report generator. This automated computing framework offers an integrated platform and a digital model for screening Autism that enables researchers and practitioners to achieve a detailed and holistic assessment of children's medical conditions to provide the appropriate diagnosis in developing nations like India with limited infrastructure.

The automated screener system is a software system that can be used by a parent or other primary caregiver of the child. Based on the responses given by the primary caregiver, the screener evaluates the child in the areas of fine and gross motor skills, social development and language skill and captures any abnormal delays in the developmental milestones. This model mainly focuses on social developmental disorder. Initially, the audience is subjected to a two-stage screening process comprised of a delay screener and a social delay screener. The delay screener (DS) evaluates the child for developmental delays in areas of motor (fine and gross), social and language milestones. The Social Delay Screener (SDS) evaluates the child in an in-depth manner on areas of social, language and cognitive functions. Thus, any delays identified in the preliminary screening are effectively further evaluated by the social delay screener (SDS). A comprehensive report generated at the end of the screening process is digitally shared to the interdisciplinary medical team which will further investigate for co-existing medical disorders such as seizures, tics, depression and complete the assessment of the child and formulate a plan for a treatment strategy involving both medical (drugs) and non-medical (artificial intelligence or AI gaming systems) therapies.

The framework offers computing-based intelligent gaming modules that are intended to improve skills of the children with special needs in areas such as social, language, emotions and cognitive functions. The AI gaming systems impart

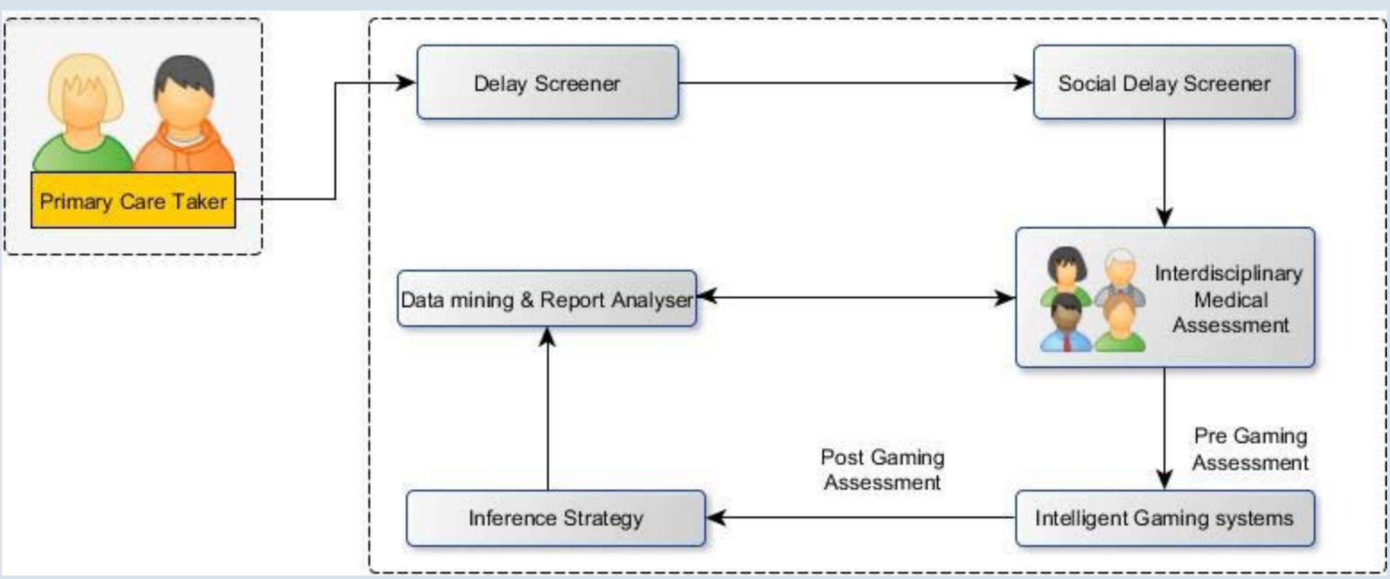


Figure 1. Framework of the system.

valuable training to the child using the agent model to which neural net and positive reinforcement agents are attached. The assessment comprises pre-training (prior to usage of AI Gaming Systems) and post-training (after usage of AI gaming systems) evaluation based on a scoring system. Once the valuable training is imparted, the medical team does assessment based on the scoring system every 3 months to evaluate the child's progress and plan the further course of management. If the results of the assessment are not satisfactory then the entire training program is repeated for a maximum of 6 months (2 cycles) until an acceptable level of improvement is attained. If the child fails to show progress even after 2 cycles of training programs, then the management plan is altered to introduce newer gaming strategies and intervention methods that are more likely to show progress.

The data gathered from the framework is stored in a data repository for further analysis. The gleaned information generated from the framework covers the following focus areas such as family, disability, needs, education, benefits received, child developmental milestones, social, language and cognition abilities. The data mining and report analyzer component summarizes the results of the screening session and additionally offers advanced data mining tools to extract meta-data about screening and training datasets. It offers more accurate description of each child's developmental progress than the traditional evaluation approach and highlights the most pressing areas that need to be addressed in the early intervention program. The tool further provides the practitioners the ability to perform data trend analysis to compare various user profiles and offers baseline data to pursue research and rehabilitation in developing newer intervention programs or in improving existing one.

III. Knowledge Based Screener

The knowledge-based screener is an advanced software solution that leverages advanced techniques in knowledge engineering and exhibits expert-level competence in facilitating the early detection of the developmental delays. As shown in Figure 2, the knowledge based screener consists of the following major components. The knowledge base is the repository of factual and heuristic knowledge. The knowledge base contains the domain expertise needed for evaluating the child's age appropriate developmental progress. An expert system tool provides one or more knowledge representation schemes for expressing knowledge about the application domain. The inference engine is responsible for manipulating the symbolic information and the knowledge in the knowledge base so as to form a line of reasoning in evaluating the user response for possible developmental delays. The knowledge base and the inference engine are the key components of the screener. The knowledge acquisition subsystem assists domain experts to build the knowledge base and provides an interface to add, update, maintain and validate the knowledge base content. The explanation subsystem gives the reasoning and explains the logical process adopted in arriving at the screener's evaluation. The explanation can range from how the final or intermediate solutions were arrived based on the evaluation. The user interface provides a platform for the end-user to interact with the system to fulfill their needs.

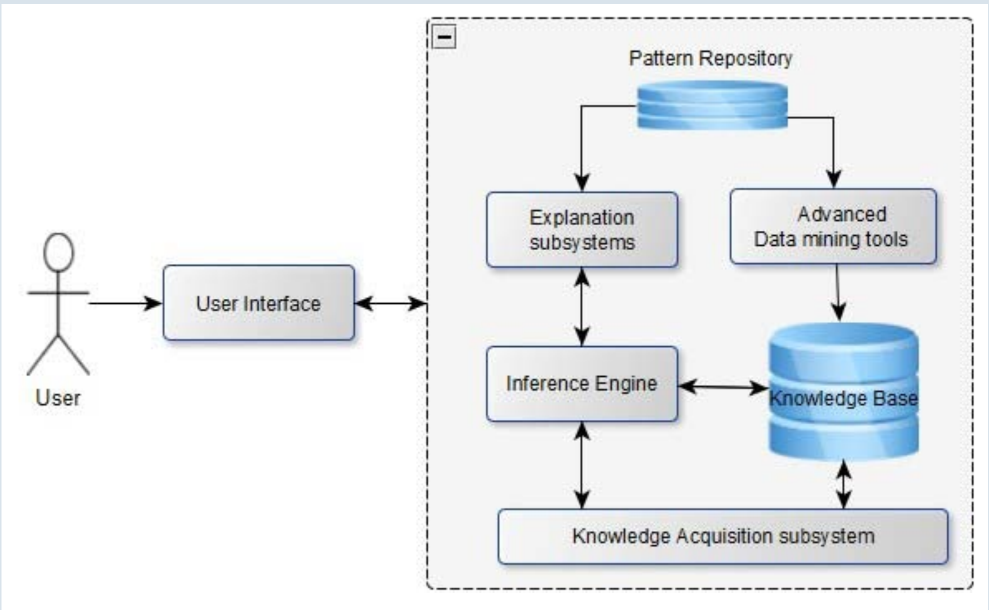


Figure 2 Architecture of the screener.

This Automated Screening System for Developmental Disorders involves a 30-minute procedure that evaluates the child's fine and gross motor, social, and language skills. The user interacts with the screener through the front end of the user interface module. The responses from the primary caregiver are subjected to detailed analysis and evaluation based on the rules defined in the knowledge base repository.

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An interdisciplinary team of specialists that cater to the needs of special needs children are involved in formulating the knowledge base of the screener which stores both the factual and heuristic knowledge. The factual knowledge is the knowledge of field that underlines the "art of good guessing." The knowledge representation formalizes and organizes the knowledge in the repository which is central to the screener's evaluation process. In our system, the knowledge is represented in terms of production rules that consist of an IF part and a THEN part (also called a condition and an action) whereas the heuristic knowledge is that of good practice, good judgment, and plausible reasoning. The IF part lists a set of conditions organized in logical combinations. The centralized repository within the framework stores and manages the production rules which represent the screening knowledge. The expert systems whose knowledge is represented in rule form are called rule-based systems. The problem-solving model or paradigm organizes and controls the steps to be taken to solve the problem. The paradigm that is implemented in the screener is chaining of the production rules to form a line of reasoning. The chaining starts from a set of conditions and moves toward some conclusion, this method is known as forward chaining. The inference engine/inference procedure provides the problem-solving methods to manipulate and use the knowledge in the knowledge base to form a line of reasoning. The screener also offers an integrated mode called the pattern mode which enables the current user profile to be matched against predefined profiles stored in the pattern repository engine. Such an integrated approach will assist effectively to determine the severity of the observed developmental delays. The advanced data mining module offers a myriad of tools to generate unique data dimensions as well as facilitate data grouping, meta-data extraction and classification on the data content stored in the repositories.

IV. Application Architecture

The framework is available in three different versions to support different computing platforms as a desktop application, web-based application for enterprise and cloud infrastructures, and mobile application. In this paper, we describe the web-based three-tiered client/server architecture of the application. As illustrated in Figure 3, the multi-tier architecture consists of a client tier, middle tier and the data tier. The client tier provides the interface to interact with the system. As a web-based solution, the client tier is accessed through the web browser. The web browser serves as a front-end that is used for user-input and for the reporting the results of the screening evaluation. During a typical session, the application gathers information on a child's age-appropriate developmental and behavioral milestones, pre-existing medical conditions, demographic details, history of any prior intervention programs and the primary caregiver's additional observations. The application then passes them on to the screener application in the middle-tier. The application provides a customized user interface to match the needs of varying end-users. The front end also provides the tools to assist the inter-disciplinary experts to select the data-centric operations and relevant parameters to perform data extraction and trend analysis over the user data repository. It also provides an administrative interface to maintain the various components of the systems such as updating the knowledge base, adding/modifying existing rules, inclusion of new case history, and updating existing

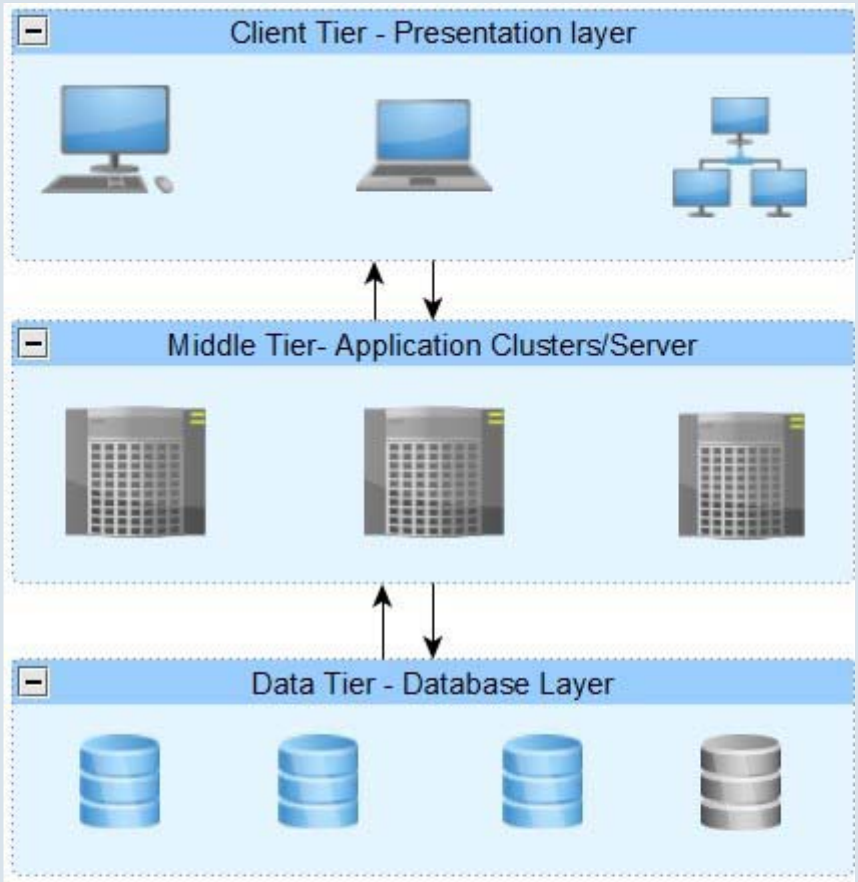

Figure 3 Application Architecture.

case history. The application supports multilingual capabilities to allow the end-user to choose their preferred language among multiple languages for system interaction. The client tiers converts the multilingual data from the user to special formatted structured data streams and forwards them to the service layer in the middle tier. The client tier contains a validation engine that validates the user's data for data consistency and integrity.

The middle tier embeds web server, application logic, application clusters and the service layers of the framework. It acts as an intermediary between the client and data tiers. The middle tier receives the data request from the client tier and transforms the request into database access operations against the repositories located in the data tier. It receives the primary caregiver's response from the client tier, applies the expert rules, application logic, case patterns, and dynamically generates the results of the screening process and shares the findings with the end-user. The middle tier controls the access to the repository in the data tier and is responsible for creating and managing a pool of database connections. To achieve the goal of developing a single application that supports multiple languages simultaneously, resource bundles are used to manage translated message files. The locale-sensitive objects such as the strings are extracted and maintained separately. This eliminates the need to rewrite the application code to support multiple languages. All the localizable resources of this application such as translated messages are stored in resource bundles.

The data tier contains the database elements such as user repository, knowledge base, pattern repository, data mining engines and provides utility to control and manage the repositories. The application generates a unique identifier for every user and eliminates the record duplication. The critical behavior and developmental observations captured during various intervention sessions, screening procedures, training and gaming sessions and medical diagnosis are stored comprehensively in the repository thereby providing an integrated platform for the team to share and analyze the data trends. The data stored in the database tables are normalized and maintains the data consistency and integrity.

V. Intelligent Gaming Systems

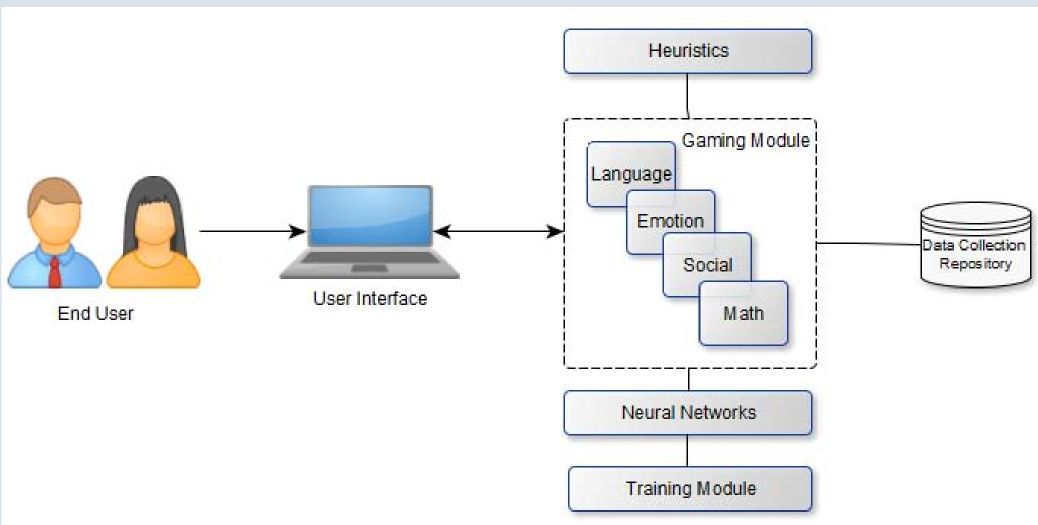

Figure 4 Architecture of the Gaming system.

Many people have noted the value of computers both therapeutically and educationally to train the people with autistic spectrum disorders. As the area of concentration is limited to the bounds of the screens of the computer, external events can be more easily ignored when focusing on a computer screen. The computers offer a context-free environment in which many people with autism feel comfortable. Therapists and teachers are increasingly using virtual reality tools to teach life skills, such as crossing the road. Many children with Autism do make eye contact, especially with familiar people. However, often what is observed is that the eye contact is less frequent than would be expected, or it is not used to effectively communicate with others [5, 6]. The aim of our intelligent gaming system is to introduce interactive games that can lead to improvements in areas of vocabulary, social interaction, cognition and attention span. The plan is to bring about these changes through the use of images of the autistic child's family members and peer groups in the intelligent gaming system. To meet the needs of regional populations, different versions of the gaming model will be available in multiple regional languages to suit individual preferences. This attempt will improve the autistic child's ability to interact with family and peers. The gaming module is developed in three different flavors: desktop application, web-based solution and mobile application to foster different computing platforms.

As depicted in Figure 4, the child under the supervision of the primary caregiver or special educators access the gaming system through the console interface. The profile of every child is ported from the screener enabling the gaming system to select training activities that match their age-appropriate skill level and treatment plan. The gaming system offers training modules across multiple areas such as language, emotion, social interaction, mathematics, cognition and attention span. The goal of the gaming model developed is to make the learning process more enjoyable and appropriate to individual needs. The underlying architecture of the gaming system agent draws on the concepts of neural networks, back propagation and reinforcement learning. The agent uses a feed forward neural network that is initialized with a random set of weights. The supervised algorithm is used in this approach while the temporal difference learning methods are employed to train the agent.

The gaming strategies consider the child's age, abilities and skills and present her/him with activities to bring in improvements. Each gaming session includes a training stage in which the child is exposed to the gaming environment followed by the test stage where their gained knowledge is evaluated. A few of the gaming modules utilize images of family members and peers in their training. The results obtained from each gaming session are recorded into the user data repository. The data mining tool offered in the framework helps in analyzing these data from the gaming sessions and highlights the pressing areas that require immediate attention. Also, the tools help the therapists to identify the hidden interests of the children based on the data gathered. If the child doesn't show improvements after the training then the strategies are changed based to bring in improvements.

The co-relation between the various focus area for development and the gaming strategies are described in the following table.

Focus Area	Gaming Strategies
Communication	The communication gaming strategies offers training and evaluation in vocabulary-based interaction so as to improve the number of meaningful words learnt, understand newer words and their meanings in different contexts, understand to speak words based on pronunciation and respond with
Social	The social skills gaming strategies are aimed to train the child on personal care, provide activities to improve interaction with family and peers, emphasize the importance of creating social relationships and foster social skills through interactive storytelling.
Cognition	The cognition and mathematical gaming strategies provide activities such as fun with numbers based on mathematics, Puzzle solving, context-based application of simple arithmetic operations in real-life situations.
Emotion	The emotional gaming strategies teach facial expressions, differentiate and relate between expressions and feelings, understanding non-verbal communications.

VI. Field Impact

Figure 5 shows the novel screening system being implemented to conduct multi-site screening initiatives across about 15 sites in south India that includes schools for children with special needs, academic institutions, and public health centers. The data collected through the novel screening system has assisted researchers and field practitioners to perform further advanced studies in autism and developmental disorders and has assisted them in studies to explore interconnections between various medical and behavioral factors and commonalities among autism and certain other conditions. This innovative system employs state-of-the-art large-scale computing technologies to provide a simple and efficient testing system that can be utilized with minimal training. This screener offers an effective method to analyze a child's development and helps the parents in identification of any

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developmental disorder at the earliest where by appropriate intervention can be instituted to improve the prognosis of the child's condition.

Figure 5 Parents attending a screening session in Chennai, India.

The screening process can be taken at home and the report is discussed with the inter- disciplinary team. Hence it has improved the effectiveness of the existing system and allays the fear of the parents about the child's developmental progress. The results achieved in the pilot study have demonstrated the screener's effectiveness in reducing the screening efforts, facilitating early intervention and treatment, increasing parental participation and public awareness. The uniqueness of this screener which combines the screening of a child for any developmental disorder including Autism, ADHD and other motor developmental delays will fulfill the need for simple and effective screening of delays. In addition, the screener is to be taken by the parent or a primary caregiver, which reduces the need for a trained healthcare professional at the early stages and reduces the strain on limited healthcare resources. The field studies on adopting the screener, have demonstrated increased parent's participation in planning therapies and implementation of the same in a cost effective manner.

VII. Conclusion

The success of technology-based humanitarian projects motivates engineers and encourages them to engage in developing technological solutions for the benefit of humanity. The main goal of our studies is to develop technological solutions that will help children with special needs and their families to overcome their barriers and create opportunities to improve the quality of their lives. The outcome of our research has demonstrated the effectiveness of engineering solutions in addressing Autism and overcoming the barriers. The results achieved have shown that engineers play a significant role in creating opportunities for individuals with special needs. At present, our team is developing an exclusive application of this framework to support the mobile platform. We are in the process of adapting these gaming strategies to support various regional languages and are developing an emotional therapy agent that focuses on improving the social and communicational skills.

Acknowledgement

We would like to acknowledge the support extended by Madhuram Narayanan Centre for exceptional children, Chennai, India in field testing the automated screening system. We express our thankfulness to all the special children, parents, doctors, special educators, mentors, research partners and volunteers participated in our research studies. "This paper is a revision of S. Veeraraghavan and K. Srinivasan, "Exploration of Autism Expert Systems," 4th International Conference on Information Technology (ITNG '07), 261-264, 2007."

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About the Authors

Mr. Sampathkumar Veeraraghavan, an internationally recognized technologist, is best known for his pioneering leadership and technological innovations in developing large-scale computing systems, advanced software technologies and systems engineering solutions to solve complex real-world computing challenges across multidisciplinary domains in the areas of healthcare, disabilities, education, security and poverty alleviation. Mr. Veeraraghavan is the founder and director of the technology-based humanitarian program "The Brahmam" (meaning knowledge), which aims to address pressing global and local humanitarian challenges in developing nations. For about a decade, he delivered technology-based sustainable programs that brought together the engineering community, Non-Government Organizations, Governmental agencies, engineers, students and disability advocacy-groups to improve the living conditions of children with disabilities, impoverished women and students in developing nations. Veeraraghavan's exemplary scholarly contributions and leadership accredited him with global honors such as the IEEE New face of Engineering, the IEEE Eta Kappa Nu "Outstanding young professional Award", Lions International Outstanding Humanitarian Engineer Award, the IEEE Global RAB GOLD achievement, the Tufts distinguished young alumni achievement award, the IEEE Asia-pacific GOLD award and the IEEE MGA achievement award. As an active IEEE volunteer, Veeraraghavan enjoys volunteering and serves in global engineering forums to promote the advancement of engineering. View his profile on IEEE.tv at https://ieeetv.ieee.org/careers/profiles-in-volunteering-veeraraghavan. Veeraraghavan is a member of the Epsilon Delta Chapter of IEEE-HKN at Tufts University.

Dr. Karthik Srinivasan is a registered medical practitioner in India. He pursued his graduate studies in public health at University of Minnesota, USA. He has lead several international large-scale healthcare projects in Uganda and India. He was working as the Consultant for Tamil Nadu Aids Initiative funded by the Bill & Melinda Gates Foundation and was instrumental in executing the HIV initiatives across the state. He is a co-inventor of the automated screening system for autism. He has graduated from Dr.MGR University, India with several awards including a GOLD medal and University rank for academic excellence.

IEEE-HKN Outstanding Young Professional Award Winner

Sampathkumar Veeraraghavan recently received the 2013 IEEE-HKN Outstanding Young Professional Award. An IEEE-HKN member, he was recognized for "inspiring leadership and exemplary seminal contribution in addressing global humanitarian challenges through technological innovations in electrical and computer engineering." He has developed several early-screening systems for infants in rural India that detect developmental delays in about 30 minutes, and Information System on Human and Health Services project involved a computing system in south India that tracks data on state-wide disabled population of more than 1 million people with disabilities.

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OUTREACH AND SUPPORT

Opportunities Abound for IEEE Members to Create Positive Impact for Humanity

Holly Schneider Brown, Program Manager, IEEE Corporate - Corporate Development

IEEE has a variety of engagement opportunities for engineers to impact society. Some of these fall under the category of what is known within IEEE as "humanitarian activities." These comprise efforts to improve the quality of life for underserved populations.

A new and vibrant program that is taking root around the world is called Special Interest Groups on Humanitarian Technology or SIGHT for short. SIGHT's aim is to inspire, enable, and connect IEEE members and the greater community to achieve social impact using technology. SIGHT groups are formed usually at the Section or Student Branch level by at least six IEEE members in good standing who are interested in carrying out projects related to humanitarian technology. (You may contact Holly Schneider Brown, IEEE SIGHT Staff Lead, at h.s.brown@ieee.org for a petition and further instructions.)

Groups have flexibility in the kinds of projects they carry out and also the subject area. Of particular interest so far are solar lighting solutions, technology education for children with limited access, and low-cost assistive technologies for children with special needs. However, the sky is the limit! Activities can range from one day workshops to long-term projects in tandem with a local non-governmental organization.

IEEE SIGHT Madras Section spread humanitarian technology among students by conducting a Solar Lamp Workshop in SRM Easwari Engineering College. The objective of the workshop is to take the knowledge on solar power to the students and kindle their interest towards developing renewable energy projects. Credit: Arun Noel Victor

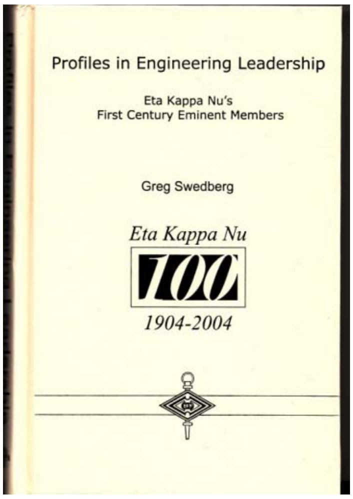
Some particularly active SIGHTs include the Universidad Diego Portales SIGHT in Chile, the IEEE Madras Section SIGHT, and the IEEE Kerala Section with multiple SIGHT groups. In March 2014, the latter Section conducted an All-Kerala SIGHT Camp.

There are 48 SIGHT groups worldwide. India has the most groups with 20. In total, Region 10 has 28 groups from Bangladesh, China, India, Indonesia, Malaysia, Pakistan, Singapore, and New Zealand. Region 9 has 11 groups spread between Argentina, Bolivia, Brazil, Chile, Colombia, Guatemala, Mexico, and Nicaragua. There are four groups in the US, two in Canada, and one technical society SIGHT: the Robotics and Automation Society SIGHT.

Members of SIGHT groups and all those interested in the program can sign up for the monthly SIGHT e-newsletter. The SIGHT newsletter features information about the program, news about SIGHT group activities around the world, calls for papers, event notices, and educational resources. For day-to-day updates on the latest happenings, look to the SIGHT Facebook group.

IEEE-HKN HISTORY SPOTLIGHT

PROFILES IN ENGINEERING LEADERSHIP



2004 marked the 100th anniversary of Eta Kappa Nu. During its first century, over 100 electrical and computer engineering leaders were elected to its highest grade: Eminent Member. A commemorative book was published that year to commemorate examples of outstanding leadership in invention, education, professional society activities, government service, and the corporate world. Among those included are Nobel Laureates Charles Townsend, Jack Kilby, and John Bardeen; pioneers Lee de Forest and Vladimir Zworykin; IEEE leaders Donald Glen Fink, Richard Gowen, and Jerome J. Suran; corporate founders William Hewlett and Simon Ramo; and leaders in government Vannevar Bush and Jerome Wiesner, to name but a few. The book contains both a brief history of Eta Kappa Nu as well as a description of the origins of the Eminent Member designation. Profiles in Engineering Leadership is available as a PDF though the IEEE Global History Network.

SIGHT will be holding several Community Engagement Workshops in 2014. These will be co-located with other IEEE events around the world. In these workshops, participants will learn about how to form a SIGHT group and conduct activities, and they will also have the opportunity to discuss and share experiences with their like-minded peers. Stay tuned to the newsletter and Facebook group for the schedule.

During the All-Kerala IEEE SIGHT Camp, volunteers traveled to a tribal village to understand the problems faced by this community and help identify solutions who implementation will be projects for the SIGHT groups in 2014. Credit: Ranjit Nair

SIGHT will hold two webinars in 2014 on topics relevant to SIGHT volunteers. However, it also recommends those interested to check out the Engineering for Change Webinar Series. This monthly series of free webinars on topics in engineering for global development is a great way to hear from subject matter experts in a variety of fields, such as energy, water, health, agriculture, structures, and more. Engineering for Change or E4C attracts a large audience of students, engineers from many disciplines, development practitioners, and more from over 70 countries. Its popular Facebook page features the latest news and opportunities for those looking to make a difference in the world using engineering.

For those interested in humanitarian technology, there will be four IEEE conferences held this year devoted to various aspects of this overarching topic: IHTC'14 - June 1 - 4 in Montreal (http://ihtc.ieee.ca), R10 HTC - Aug 6 - 9 in Chennai (http://ieeer10htc.org), GHTC SAS - Sept 26-27 in Trivandrum (www.ghtc-sas.org), and GHTC - Oct 10 - 13 in San Jose, CA (www.ieeeghtc.org).

These are great opportunities to meet face-to-face and learn from a broad pool of stakeholders all focused on developing effective solutions to local challenges.

IMPACTING YOUR LOCAL COMMUNITY, ONE PROJECT AT A TIME

ENGINEERING PROJECTS IN COMMUNITY SERVICE

By Allyson Dwyer, EPICS in IEEE Administrator

Engineering Projects in Community Service (EPICS) in IEEE is on a mission: to empower university and high school students, and their local communities; to foster collaboration between young engineers and non-profit organizations; to encourage pre-university students to consider continued studies in engineering; and to give university students opportunities to hone their professional skills. To date, the program has funded over fifty projects in multiple IEEE regions, across North and South America, Europe, Africa and Asia, with approximately 120,000 people, from residents to visitors to school children, benefitting from funded projects worldwide.

Joyce Namakula from Luweero district (Uganda) using a solar phone charger to charge mobile phones. The solution was developed by the engineering students of Kyambogo University and Agha-Khan high school during the developed the EPICS in IEEE project titled "Kyambogo University and Agha Khan Poverty Reduction and Environmental Conservation through Solar Powered Solutions." Photo credit: Lwanga Herbert

But what is EPICS? EPICS in IEEE was inspired by the EPICS program, which was championed by IEEE 2007 President Leah Jamieson, and Edward J. Coyle, at Purdue University in Indiana, USA, in 1995. This original inception of EPICS involved university students in service learning activities (EPICS University), and was replicated to organize high school students in 2006 (EPICS High) for similar activities. EPICS in IEEE involves local student branches, high schools students and non-profit organizations to work on community service issues together in locations around the world.

These forms of hands-on learning have a distinct impact on each individual who becomes involved in an EPICS in IEEE project.

> *"I find this as an excellent opportunity working with engineering students, and I feel more committed to the society. Also, my involvement in the project has made me more conscious about Road Safety. I would like to become an engineer occupied in developing technology for automated traffic control for the people in our country."*
> *-- Comments by a student participant in the project "Synchronous Traffic Control System" at IES College of Engineering, Kerala, India*

In 2009, the EPICS in IEEE pilot program received a grant from the IEEE New Initiative Committee, and developed the program's first two pilot programs. One, which took place in North America, was titled "Clean Air Council - Air Quality Monitoring," and occurred at Drexel University in Philadelphia, Pennsylvania. The second pilot project occurred at

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Cape Town University in South Africa, and was titled "Western Cape Breeze." These two projects provided the framework that would be the basis for following projects in the program.

Today, the program continues to thrive due to the work of an international EPICS in IEEE committee, and initiative leaders, Dr. Kapil Dandekar, and Educational Activities Board Vice President, Dr. Saurabh Sinha. Each project is asked to also select a project category of pre-defined EPICS in IEEE classifications:

- Access & Abilities
- Educational & Outreach
- Environment
- Human Services

However, projects do not have to limit themselves to one category. Some projects can address Access & Abilities with a solution that is also environmental, such as the first project approved in Uganda, in 2010, titled "Poverty Reduction and Environmental Conservation Through Solar Powered Solutions" at Kyambogo University. Twelve students from the university partnered with local non-profit organization LOG'EL Project, and high school students from Agha Khan High School, to design, build and install environmentally friendly solar powered phone chargers and charging controllers for low income communities.

In 2012, the University of Cape Town project "Modelling and Installation of Solar Water Geyser + Photovoltaic Power Generation at Emasithandane Children's Home in Nyanga" was approved. Seven graduate students and two undergraduate university students partnered with several local non-profit organizations and high school students to build a model of a complete solar water heating system, which was installed at the children's home. The installation of this system helped sixty people, ranging from toddlers to the elderly, to gain access to hot water and other facilities. This was an Access & Abilities project with an Environmental solution.

Since its implementation, the EPICS in IEEE program has had profound impact on many groups large and small. To date, 186 volunteers, 85 graduate students, 333 undergraduate students, and 794 middle or high school students have been in involved in a project. The program also looks to encourage underrepresented groups, such as young women, to take on an interest in engineering.

EPICS in IEEE receives applications all year long, and even the smallest of ambitions can help contributed to the program's growing impact. We encourage students to get involved, because experience in an EPICS in IEEE project not only helps you to grow professionally, but lift up fellow students as well, and the local community your project effects. One simple step to organizing a project can lead to a journey that is rewarding for you and the world.

For questions, please contact the EPICS in IEEE program at epics-high@ieee.org, or visit our website www.ieee.org/go/epics-high.

Undergraduate students develop projects in the Assistive Technology Lab of Shri Vishnu Engineering College for Women in Bhimavaram, India. Photo credit: Dr. Pushpa Kotipalli.

Wearable Sensors and Systems

From Enabling Technology to Clinical Applications

By Paolo Bonato

Image Credit: Takao Someya Group, University of Tokyo

Over the past decade, wearable technology has gained the interest of researchers and clinicians [1]. The motivation for the development of wearable sensors and systems is due to the tremendous benefits that could be associated with long-term monitoring of individuals in the home and community settings. For example, in Figure 1, an individual affected by a balance disorder is monitored while at the gym or a clinical center (e.g., undergoing balance training). Here, exercise compliance and performance are monitored via motion sensors attached to the wrists and ankles: the interaction with a parallel bar setup is captured by sensorized gloves that track hand movements, and physiological responses to the exercise are gathered using a chest strap that enables monitoring of heart rate and respiratory rate. The subject carries a cell phone in his/her pocket, which serves as data logger (i.e., the cell phone ''talks'' to the sensors positioned on the body) and as a gateway for remote access to the subject's data. Access to the subject's data is achieved via a cell phone network or via a wireless local area network. Data are then relayed via the Internet to emergency personnel (e.g., an ambulance service), a family member or caregiver, and clinical personnel (e.g., the subject's primary care physician) as needed to respond to emergency situations, assess the subject's status, and plan clinical interventions.

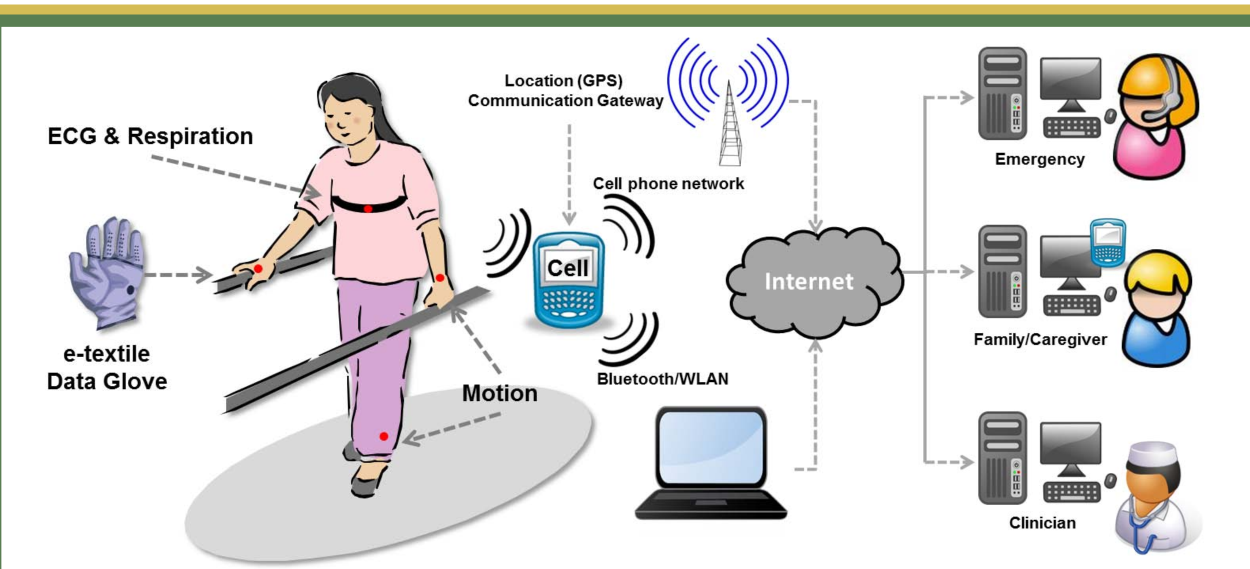

Fig. 1. Schematic representation of a system for patients' monitoring in the home and community settings. A subject is shown while exercising at the gym (e.g., undergoing balance therapy). Exercise compliance, exercise performance, and the associated physiological responses (i.e., heart rate and respiratory rate) are monitored via wearable sensors. A cell phone serves as a data logger and gateway for communication with a remote location via a cell phone network and/or the Internet.

A Decade of Development of Wearable Technology

Interest in monitoring individuals in the home and community settings is not new and is in fact one of the factors that originated the field of telemedicine (recently renamed as connected health to emphasize the link between clinical personnel and patients that has been made possible by communication technologies such as the Internet). Researchers believe that long-term monitoring of physiological data could lead to significant improvements in the diagnosis and treatment of cardiovascular diseases [2]. It could, for instance, overcome shortcomings of currently available technology (e.g., Holter monitoring), such as the inability of capturing rarely occurring events of diagnostic relevance. Home monitoring of movement patterns in patients with motor disorders also could have a dramatic impact on the clinical management of impairing symptoms. For example, monitoring the severity of parkinsonian symptoms could facilitate medication titration as the disease progresses, thus minimizing impairments associated with severe dyskinesia, bradykinesia, rigidity, and akinesia. Researchers envisioned the potential benefits of field monitoring of patients with Parkinson's disease since the early 1990s [3], [4]. However, technological limitations prevented the immediate clinical application of the methodologies proposed.

Starting in the late 1990s, a tremendous effort has been made in the field of wearable technology toward closing the gap between vision and reality. Researchers have been engaged in developing technologies to enable the shared vision that long-term home monitoring could revolutionize the way medicine is practiced and have focused on two major approaches to implement wearable systems. These two distinct approaches leverage wireless technology and e-textile solutions, respectively [5]. It could be argued that this is purely a technology-based distinction and that future clinical systems will most likely combine wireless and e-textile technologies according to the requirements of the application at hand. However, hybrid systems integrating wireless and e-textile technologies still appear to be a futuristic possibility. Research groups in the field of wearable technology are typically focused on one technology or the other, since the technical expertise necessary to develop systems leveraging both technologies (i.e., wireless and e-textile) are very different and rarely found in a single research group.

The development of wearable systems based on wireless technology leverages the miniaturization of sensors, availability of low-power radios, and development of dedicated operating systems (e.g., TinyOS) for small sensor units and networks of sensor units. Such networks are referred to as body sensor networks, and the sensor units are referred to as sensor nodes. A schematic representation of a body sensor network is shown in Figure 2. In the figure, a SHIMMER unit [6] is displayed as an example of a sensor node. A subject is depicted with sensor nodes attached to wrists and ankles, a setup suitable to monitor major motor activities. A chest strap is used to monitor heart rate and respiratory rate, thus capturing physiological responses to motor activities and potential cardiovascular problems that can be detected, for instance, via analysis of the heart rate and its variability. The nodes communicate with a base station (not shown in the figure) that could be either a data logger worn by the subject or a computer located in the environment surrounding the subject.

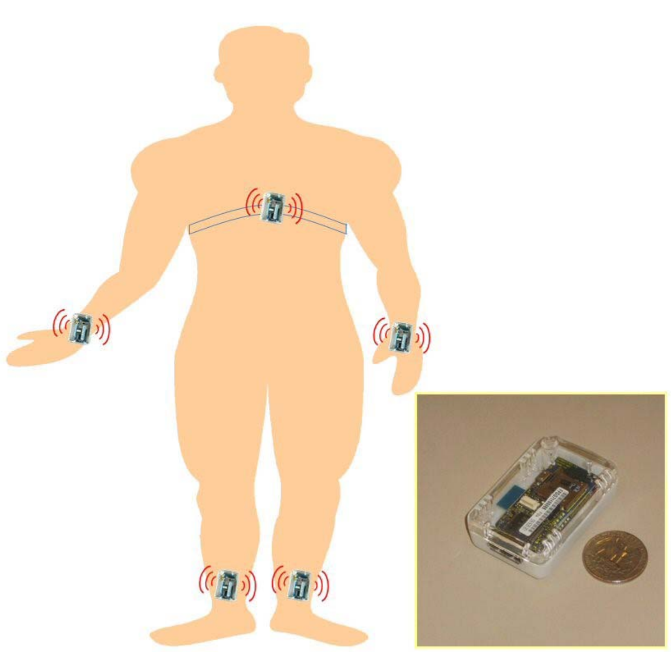

Fig. 2. Schematic representation of a wearable system that allows one to collect movement and physiological data (i.e., heart rate and respiratory rate). Movement data are gathered using the four nodes equipped with accelerometers that are strapped around the ankles and wrists. Physiological data are collected via a chest strap.

Advances in sensor technology have been essential to the implementation of body sensor networks. Researchers have put a great deal of effort on developing ways to unobtrusively monitor vital signs, with a particular emphasis on cardiac activity. Seminal work contributed by the group led by Asada and coworkers [7], [8] resulted in the ring sensor, a ring-shaped photoplethysmographic sensor capable of transmitting data wirelessly to a base station, which provides the ability to monitor heart rate and oxygen in the blood. More recently,Wang et al. [9] developed an earpiece photoplethysmographic sensor that has light-emitting diodes and photodiodes positioned around the outer ear—as opposed to being attached to the earlobe as are commercially available photoplethysmographic sensors—thus leading to improved comfort. Also, Vogel et al. [10] developed an in-ear sensor suitable to record heart rate and, in the future, oxygen in the blood. Unobtrusive blood pressure monitoring has also been the focus of significant research efforts. Wristwatch type monitors, such as the MediWatch [11], were first developed by leveraging the miniaturization of sensors based on traditional approaches to measure blood pressure (i.e., via blood flow temporary obstruction). More recently, researchers have focused their work in this field on the pulse transit time technique [12], [13]. The technique leverages the relationship between blood pressure and the time between the R-peak of the electrocardiogram and a peak identified on the photoplethysmogram. Furthermore, researchers interested in tracking patients' movement patterns have been relying on the advances that have marked the field of microelectromechanical systems over the past two decades. Thanks to the progress in this field, sensors like accelerometers, gyroscopes, and magnetometers are now available that meet the requirements (e.g., low power consumption) for use as part of a body sensor network. Using this technology, researchers and clinicians can currently monitor subjects' movement patterns and possibly even reconstruct movement trajectories [14]. Advances in sensor technology have been combined with progress in short-range communication technologies such as ultrawideband radio technology [15], Bluetooth [16], and ZigBee [17] that have enabled the implementation of body sensor networks. Seminal work in this field by Jovanov et al. [17] has been followed by extensive work toward the development of strategies aimed at optimizing the scarce resources available on the nodes of body sensor networks [18]. This latter work has required the development of operating systems specifically designed for body sensor networks.

Advances in e-textile research have paralleled the vast achievements in body sensor networks. Seminal work in this area was performed at Georgia Tech, where researchers developed the Wearable Motherboard or Smart Shirt [19]–[21]. The concept pursued by researchers at Georgia Tech, led by Jayaraman, was one of transforming the clothing items into an equivalent of a computer bus by attaching sensors, for example, to an undergarment that could communicate with a data logger positioned on the subject (e.g., at waist level). This concept led to different implementations and, eventually, commercially available products. An example of a research platform of this type is shown in Figure 3(a), which is developed by Wade and Asada [22]. In this implementation, traditional sensor technology is embedded in special buttons that carry sensor technology and that clip onto the fabric in away that allows an electrical connection with a data logger positioned at waist level via the garment. The layers of the garment provide electrical characteristics that allow one to use the garment itself as a modem line, thus providing a means to send data from the sensors to the data logger.

Fig. 3. Examples of e-textile technologies developed over the past ten years. (a) A system developed by Wade and Asada [22] relying upon special buttons that carry sensor technology to record physiological and movement data. (b) A system developed by De Rossi's research team [23] for monitoring the movements of the shoulder and elbow via recordings of the voltage drop on conductive elastomers that are printed on the garment. (Figures used with permission.)

Others have attempted the actual development and integration of sensing elements into garments using new materials and techniques to integrate sensors and fabric. De

Rossi's group has provided a unique contribution in this field [23], [24]. Figure 3(b) shows an example of a technology developed in his laboratory. Conductive elastomers are printed on a lycra shirt and provide a means to monitor movements of shoulder and elbow. The method leverages changes in resistance of the sensing elements that occur as they are stretched or released during the movement of body segments. Such changes are detected using a circuitry that injects a small constant current into the sensing elements and by means of a dedicated high-impedance amplification unit that reads changes in voltage drop on the sensing elements that are associated with changes in their resistance. Current research focuses on the implementation of a new generation of textile sensors [24]. These new technologies are expected to allow one to seamlessly record electrocardiogram data, monitor respiratory rate, track changes in blood oxygenation, and monitor sweat rate.

Wireless and e-textile technologies are now integrated into wearable systems that fulfill the promise of subjects' long term monitoring in the home and community settings. Researchers are relying on data loggers with advanced communication capabilities (such as Internet tablets and smartphones) to gather data from wearable sensors and relay clinical information to a remote location [25]–[27]. Although technical problems still hamper the deployment of these systems (e.g., difficulties managing the resources of smartphones thus leading to rapidly depleting the phone battery), this is a fast evolving field that has shown incredible transformations over the past few years, and therefore, it is anticipated that these issues will be soon addressed. Among others, the development of open-source smartphone platforms promises to make available to researchers and developers an array of tools that will likely result into suitable solutions for an effective integration of smartphones into wearable systems.

The body of work summarized earlier is by no means a complete review of the advances that we have witnessed over the past decade in the field of wearable sensors and systems. However, it provides an overview of the efforts and results achieved by researchers in the field of wearable technology toward developing systems that are suitable for clinical applications. In the past, lack of suitable platforms for unobtrusive long-term monitoring of individuals in the home and community settings hindered the application of wearable technology to concrete clinical problems. Advances achieved in this field over the past decade have made available to researchers and clinicians the tools needed to pursue clinical studies. As a consequence, we are currently witnessing a flourishing of research efforts focused on assessing the use of wearable sensors and systems to prevent diseases, promptly respond to emergency situations, and optimally manage chronic diseases. This is expected to be the focus of the field for the next five to ten years. Preliminary results summarized later suggest that major clinical applications of wearable technology are just around the corner.

Shifting the Focus on Clinical Applications

Clinical applications enabled by wearable systems can be categorized according to how their design addresses the three main challenges inherent in monitoring individuals in the home and community settings. These challenges are captured by the following three questions.

1. How critical is the information to be gathered and relayed by the wearable system?
2. How long will the subject wear the system and during performance of what type of motor activities?
3. How quickly will it be necessary to relay the information gathered by the wearable system to a remote site?

These questions work to define how applications of wearable technologies have been pursued in the recent past and are currently pursued with renewed effort, thanks to the advances in wearable sensors and systems described earlier. Knowing whether the information gathered via wearable systems is critical to the management of emergency situations or to the prevention and diagnosis of diseases has somewhat determined the level of comfort of researchers and developers in the private sector in pursuing related applications. When critical information needs to be recorded and potentially processed by the system, developers must use stringent criteria for the assessment of the reliability of the data. They also need to consider the liability of the company manufacturing the wearable system. It follows that research and development activities focused on these applications proceed slowly compared with research and development activities that address applications handling information that is not as critical. How long a subject needs to wear the system to gather relevant information also appears to be a determinant factor in making a decision about pursuing the applications of wearable technology. The longer a subject has to be monitored, the more stringent will be

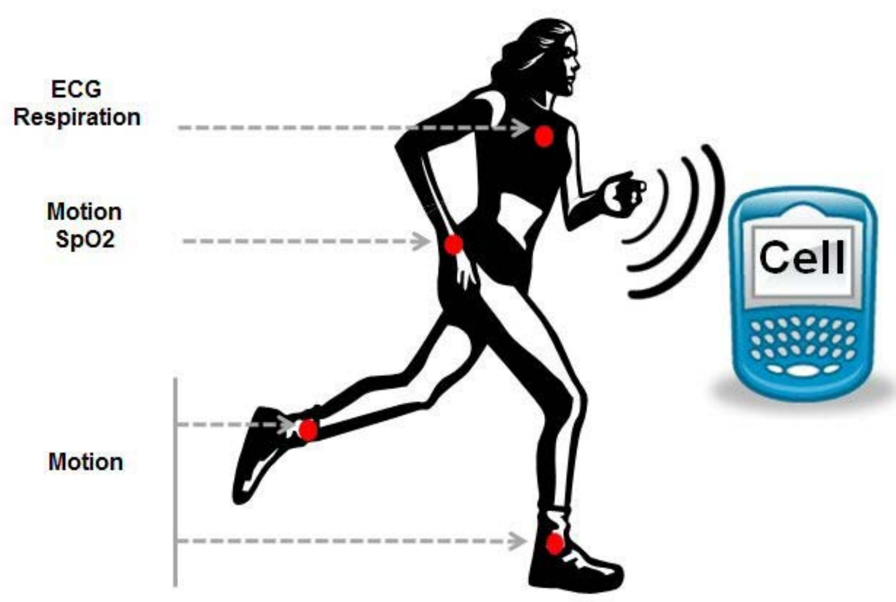

Fig. 4. An important application of wearable technology consists of monitoring individuals while they exercise. The focus here is on wellness/fitness monitoring, with the potential development of methodologies to improve exercise compliance. Wearable sensors allow one to monitor movement, respiratory rate, and heart rate. ECG: electrocardiographic recordings; SpO2: oxygen saturation.

the specifications concerning unobtrusiveness of the system and its wearability. Consequently, the first applications researchers have focused their attention on require only sporadic data sampling. In other terms, the system is donned and doffed as needed but not used for continuous monitoring 24 hours a day, 7 days a week.

Similarly, the type of activity individuals are engaged in significantly affects the system requirements. For instance, if subjects are monitored while exercising, the quality of physiological data gathered by the wearable system will be a concern, because movement artifacts so often negatively affect the quality of physiological signals. Finally, applications in which critical information must be gathered by the wearable system and used to generate alarm messages for immediate response to a life-threatening situation present challenges that only complex systems that have undergone extensive testing can meet. The full development of such systems is yet to come, as only recently reliable technologies that meet the specifications of this type of monitoring have been made available.

These considerations justify the initial focus of researchers and developers in the field of wearable sensors and systems on wellness [28]-[30] and activity monitoring [31]-[36]. Figure 4 schematically represents a common application of wearable technology in this context. In the figure, a runner's heart rate, respiratory rate, and motion are monitored using wearable sensors. A cell phone provides data-logging capability and connectivity. Commercially available systems already provide the capability shown in Figure 4, including the ability to locate the subject via solutions based on a global positioning system. This ability enables a runner to follow his/her position on a running course via a display unit mounted on the wrist and to compare performance from one day to another while running or after completing the running course. Wearable solutions are also used by runners to pace themselves by playing suitable music using anMP3 device wirelessly connected to sensors embedded in the subject's shoes that also track his/her pace.

Wellness applications of the type described earlier should not be dismissed as mere gizmos. They have, in fact, a great potential to increase exercise compliance in populations at risk. Obesity management is an example where application of wearable systems that support wellness could be implemented [37]–[40]. It is well known that we face an obesity epidemic and that the weight management industry is a huge business that delivers very limited results. More effective tools are required in the fight against obesity, and wearable sensors and systems have the potential to provide new tools to support and encourage healthy choices. For example, smartphones and software applications can be designed to display activity profiles comparing target levels and actual levels of activity as assessed via processing data gathered using wearable sensors. Subjects could then be encouraged to increase their activity level via presentation of this type of information on the smartphone display. Furthermore, the use of a global positioning system and contextual information (e.g., the time of the day and the proximity to a cafeteria) would trigger positive messages about decreasing calorie intake by suggesting healthy nutritional choices. The potential impact of tools of this type on preventing diseases and chronic conditions such as diabetes and cardiovascular diseases is significant, and

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current research continues to make positive strides in this direction.

Paralleling the progress in wearable technology, applications gradually shifted their focus toward medical problems that require enhanced reliability compared with systems designed for wellness applications. Monitoring patients with Parkinson's disease to improve clinical management of symptoms is an example of one such type of application. Currently, clinical visits are inadequate to sample the severity of parkinsonian symptoms, because symptoms vary in response to a medication dosage with a time constant of hours, a time interval that does not lend itself to direct patient observation by clinical personnel. Furthermore, patients do not have an objective perception of their own motor status, and thus they cannot report reliably about the severity of their symptoms and their response to a medication adjustment. Patients often mix up symptoms (e.g., tremor and dyskinesia) that require opposite adjustments in medication intake.

Wearable technology has the potential for addressing these problems by providing a means of gathering objective measures of the severity of symptoms over a period of time sufficient, for instance, to reliably assess the effectiveness of medication adjustments. Seminal work by Ghika et al. [3] and Spieker et al. [4] exploring the use of sensor technology to capture the severity of parkinsonian symptoms was followed by the work by Keijsers et al. [41]-[43] aimed at assessing the effectiveness of medications in attenuating the severity of symptoms using wearable sensors. More recent research has been focused on integrating and further developing these techniques into complete wearable systems for home monitoring of patients with Parkinson's disease [44]-[46]. We anticipate that home monitoring of patients with Parkinson's disease will be integrated in the near future with remote assessment tools leveraging videoconferencing and remote access to sensor data to facilitate clinical evaluation of the severity of parkinsonian symptoms. Figure 5 shows a software application recently developed by Matt Welsh's research team and my research team (supported by the Michael J. Fox Foundation) as part of a joint effort toward the development of Web-based applications devoted to the collection of data from patients with Parkinson's disease in a home environment. The system integrates wearable technology and advanced signal processing algorithms to relevant information gathered to determine whether a medication adjustment is needed. The project has the overall objective of facilitating clinical management of parkinsonian symptoms in patients at the late stages of the disease.

The screenshot shown in Figure 5 is the software interface for personnel overseeing the remote clinical evaluation of a patient with Parkinson's disease. The session in Figure 5 is a simulation in which a subject posing as a clinician instructs a subject posing as a patient to perform motor tasks associated with the motor section of the Unified Parkinson's Disease Rating Scale, a clinical scale designed to assess the severity of parkinsonian symptoms [47]. Data gathered using a body sensor network are collected by a laptop computer (the patient's workstation) and relayed to the clinical site via the Internet. As the display of data on the clinician's computer screen occurs online, the clinician has the opportunity to spot-check the quality of data

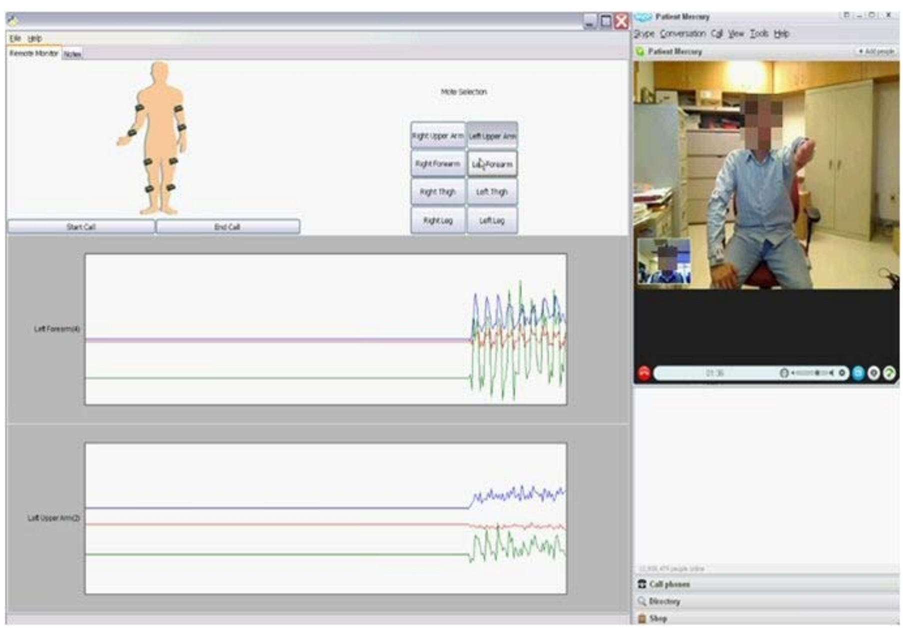

Fig. 5. Home-monitoring applications would often benefit from technology for remote examination of patients. The screen capture presented shows the graphical interface of an application recently developed by Matt Welsh's research team at Harvard University to monitor patients with Parkinson's disease in the home. The software application provides clinicians with access to wearable sensor data and measures the severity of parkinsonian symptoms [45].

gathered during the session.

Similar applications have been pursued to monitor cardiovascular diseases such as congestive heart failure, which requires long-term monitoring of patients to detect worsening of patient status, and to set in place prompt interventions that might prevent hospitalization [48]–[50]. It is worth emphasizing that these applications can be seen as fulfilling the vision that led to the proposal of Holter monitoring in the late 1940s and its clinical adoption in the 1960s. Although Holter monitors have provided an invaluable tool to diagnose cardiovascular diseases over the past 50 years it could be argued that only by leveraging wearable technology can the vision that originated Holter monitoring be fully implemented.

While applications described earlier have significant potential clinical impact, they still fall within a group of applications that do not require prompt interventions in response to an emergency situation that would be detected based on the analysis of data gathered using the wearable system. In other words, these applications are designed around a clinical response with a relatively long time constant, namely, a few days. However, a new set of clinical applications of wearable systems is currently emerging that requires either a response within a few hours or an immediate clinical response, as sensor data gathered in such applications are meant to detect emergency situations. Applications that fall in this category include monitoring patients with chronic obstructive pulmonary disease to achieve early detection of exacerbation episodes, monitoring patients with epilepsy to detect the occurrence of seizures, and monitoring individuals to detect and potentially prevent sudden cardiac arrest. These are all applications of great relevance because of the potential-related improvement of patients' quality of life and because of the significant potential impact on the society at large.

In patients with chronic obstructive pulmonary disease, early detection of exacerbation episodes would break the downward spiral that characterizes these patients who worsen every time they experience an exacerbation episode -- a worsening from which they never fully recover -- leading to a progressive decline of their clinical status. In patients with epilepsy, the detection of seizure events could potentially prevent severe accidents and even death if the patient falls unconscious and clinical care is not provided promptly. In individuals at risk of sudden cardiac arrest, continuous monitoring of heart rate could provide a means to guarantee that clinical care is immediately provided if the heart suddenly stops beating.

The applications of wearable sensors and systems summarized in this section demonstrate the potential of this technology for achieving prevention and diagnosis of several diseases and for optimally managing chronic conditions. Some of these applications, specifically those related to wellness management, have already led to commercially available systems. More challenging clinical applications such as the use of wearable sensors and systems to facilitate the titration of medications in chronic conditions (e.g., Parkinson's disease) are bound to become clinical tools within a few years. The need for high reliability of the system, as required by clinical applications with a focus on providing an alarm that guarantees prompt interventions in response to emergency situations, still requires both technology development and clinical testing. New trends merging wearable technology and robotics appear to have the potential for opening the way toward improved home interventions and achieving higher reliability in the detection of emergency situations.

New Trends: Integrating Wearable Technology and Robots

The combination of wearable technology and robots is a very recent development in the field of wearable sensors and systems [51], [52]. Interest in this approach originates from the observation that subjects with chronic conditions (such as hemiparesis following a stroke) could benefit from therapeutic interventions that can be facilitated by robotic systems and enhanced by wearable technology. Figure 6 provides an example of how robotic and wearable technologies can be combined to deliver therapeutic interventions. In the simulated clinical session shown in Figure 6, a subject is posing as a patient with hemiparesis undergoing therapy. An exoskeleton-type system provides support to the hemiparetic arm, thus facilitating the performance of movements. The position of the exoskeleton is tracked using sensors embedded in the device. The output of the tracking algorithm is used to play video games designed to encourage the patient to perform motor tasks such as reaching and grasping/retrieving objects. Performance of these motor tasks is known to have positive therapeutic effects when subjects perform a high number of movement repetitions. A sensorized glove is used to track hand grasp/release movements, thus providing a platform for the implementation of exercises focused on the recovery of hand function.

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Fig. 6. Rehabilitation robotics is combined with wearable technology for the purpose of enhancing functions that are not provided by robotic systems [51]. Features provided by commercially available robotic systems like the one shown in this figure (Armeo by Hocoma AG) can be augmented via the use of wearable sensors. In the example presented, a sensorized glove provides the system with the ability to implement exercises targeting the recovery of hand function. This capability would not be available if the robot were to be used alone.

The aforementioned approach is expected to benefit subjects undergoing physical therapy to recover arm and hand functions. The combination of wearable technology (i.e., the sensorized glove) and robotics allows one to improve the quality of the intervention. The robot alone does not lend itself to the implementation of therapeutic exercises that focus on hand function, an aspect of physical therapy that is known to be of paramount importance when one aims at achieving recovery of the subject's functional capability. The sensorized glove is therefore a key factor in improving the clinical intervention in the presented application scenario. Patients that are candidates for the use of these technologies include individuals who have suffered a stroke, a traumatic brain injury, or experienced other neurological problems leading to impairments and functional limitations of the upper limbs.

It is important to note that traditional physical therapy techniques could theoretically lead to similar results to the ones expected from robotic therapy (although recent research suggests that robotic therapy leveraging interactive games leads to better results than therapeutic interventions simply based on delivering a high number of repetitions of specific movements [53]). However, the intensity of the exercise that has been shown to benefit patients when robotics is relied upon cannot be achieved in the current health-care system model by means of traditional interventions based on manual therapy administered by clinical personnel in a one-to-one ratio with patients (i.e., with one therapist working with a single patient at a time). This is because the number of physical therapy sessions that are reimbursed by insurance companies is limited. Also, it must be observed that a higher number of movement repetitions can be achieved within a single session using robotics compared with traditional therapeutic interventions. In this context, wearable technology provides a means to enhance available rehabilitation robotic platforms that lack adequate focus on exercises devoted to the recovery of hand function.

The future of these technologies is in the home. Home-care services would oversee the use of systems like the one described earlier implemented in a home setting. During their visits, therapists would instruct patients on the correct ways to perform therapeutic exercises using the robot and combined wearable technology. Patients would exercise using interactive games that rely on the hardware provided by the home-care service. Data concerning exercise compliance and performance would be logged by the system for later review by the therapist and patient. The data would also be relayed to a clinical center for monitoring purposes so that immediate action can be taken if necessary (e.g., a telerehabilitation session could be set up if inappropriate patterns of movement are observed via review of data collected during performance of a home-exercise session).

In addition to improving the effectiveness of interventions by combining rehabilitation robots and wearable technology, one can think of a number of other applications that would be facilitated by the deployment of robotic and wearable technologies in the home. Major changes could rapidly occur in the field if home robots were combined with wearable technology, as schematically represented in Figure 7. In this example, a wearable sensor suit is used to monitor movement and physiological data [Figure 7(a)], and the suit communicates wirelessly with a home robot [Figure 7(b)]. The figure shows a picture of the iRobot ConnectR (courtesy of iRobot). This system has features including a Web camera and Internet capability. In this way, leveraging wearable technology and home robots could have a dramatic impact in the field of clinical home monitoring.

Fig. 7. It is envisioned that combining (a) wearable technology and (b) home robots will result in novel home-monitoring applications. Wearable sensors will communicate wirelessly with home robots (image courtesy of iRobot) that will in turn respond to alarm messages using onboard capabilities (i.e., image processing) to interact with the patient and assess the severity of the situation.

Additionally, Figure 8 shows a range of clinical applications that could be pursued if one leveraged home robots and wearable technology. The platform depicted in Figure 8 is complex and relies upon a combination of wearable sensors, home robots, interactive gaming, and other technologies (e.g., cell phone and Internet tablet) to develop a connected health application for patients with balance disorders. The system assesses fall risk via monitoring stride variability, facilitates interventions delivered using interactive gaming systems, and detects falls via the combined use of wearable sensors and a home robot.

Methods for the assessment of fall risk based on the variability of gait that have been proposed in recent years [54], [55] could be implemented using the platform shown in Figure 8. Wearable sensors attached to the ankles would allow one to detect foot strike events and estimate stride-to-stride variations in the duration of the gait cycle. The platform shown in Figure 8 would also provide connectivity with interactive gaming systems like the Nintendo Wii. Physical and occupational therapists have demonstrated a growing interest in the use of off-the-shelf interactive gaming systems as a tool that complements traditional clinical interventions. The use of off-the-shelf interactive gaming systems is very attractive in the context of implementing home interventions, but commercially available systems lack the ability of monitoring movement patterns in a way that is satisfactory from a rehabilitation intervention standpoint. While using interactive gaming systems, subjects must be encouraged to use appropriate motor control strategies (rather than compensatory mechanisms). In the scenario shown in Figure 8, the system would provide appropriate feedback during the performance of home exercises, based on the analysis of data recorded using wearable sensors. The sensors would be used to monitor movement patterns, and a home robot would be relied upon to convey feedback to the individual. Finally, wearable sensors and home robotics would be combined to achieve prompt detection of falls in the home environment. A key factor in minimizing the severity of fall-related injuries is to promptly detect the fall event and alert clinical personnel. During the past decade, a number of devices for fall detection have been developed by researchers [56]–[60], and fall-detection devices have been introduced on the market. These systems are typically based on body-worn units (e.g., pendants and wrist straps) equipped with an accelerometer. The units are programmed to detect falls based on the analysis of accelerometer data and to send an alarm message to a caregiver. Unfortunately, the potential benefit of these systems is limited by poor compliance, because subjects are overwhelmed by the large number of false detections of falls (i.e., false positives) that mark existing systems. This is somehow inevitable because fall-detection systems have to be extremely

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sensitive to the occurrence of a fall. To achieve high sensitivity, low specificity (i.e., high rate of false detections) has to be tolerated. In the system shown in Figure 8, a home robot is combined with the use of a body-worn unit to minimize the number of false positives. The body-worn unit sends a message to the robot when the unit detects a fall. The robot responds by using a combination of video processing and human–robot interaction techniques to assess whether the subject actually fell. If the robot determines that the subject fell or if it cannot determine whether the individual fell, it alerts a caregiver. The caregiver has the ability of teleoperating the robot to determine if the individual fell, and if so, how urgently is attention to the situation required. This approach based on assessing potential fall events with a home robot has the potential to significantly improve the effectiveness of fall-detection systems. By autonomously eliminating a large number of false positives and allowing for a rapid assessment of the severity of true positives, the system allows precious human care-giving resources to be deployed in the most efficient and effective manner.

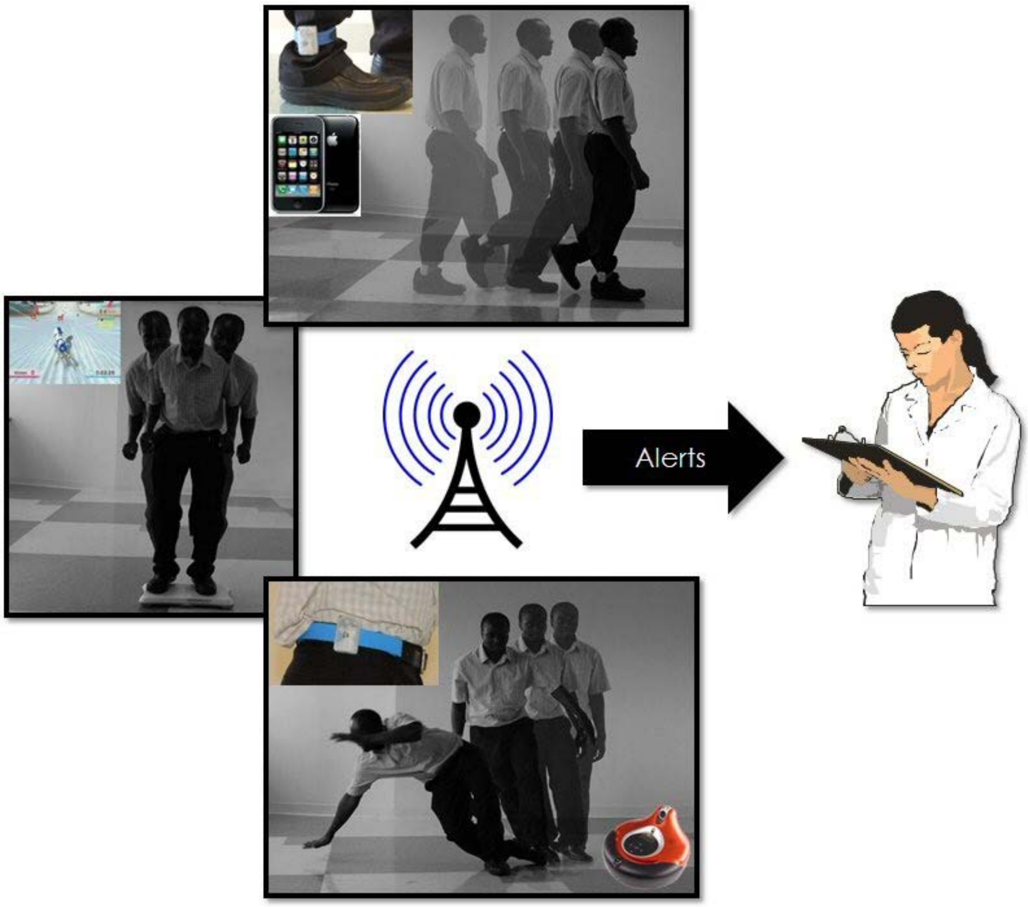

Fig. 8. Complex systems under development will soon provide enhanced monitoring capability, the ability to facilitate clinical interventions, and features that are suitable for detecting emergency situations, assess needs (e.g., via gathering images and other information using a home robot), and alert a remote clinical center when necessary.

It is worth noting that the combination of home robots and wearable technology is somewhat complementary to installing sensing components in living environments [61]. Although some applications might be better served by sensing components installed in the home [62], [63], the use of home robots has a significant potential for decreasing costs and mitigating the level of obtrusiveness of the monitoring system. It is known that robots are often perceived by people as pets. Therefore, one would expect that a home robot would be more easily accepted than a set of Web cameras positioned in all the rooms of the home. Home robots are also easier to control, and they provide the assurance that privacy is not violated. For instance, the camera positioned on the robot can be easily flipped so that the lens does not face the subject, thus reassuring individuals that the privacy is not violated even by mistake. Besides, remote control of home robots provides a flexibility of interaction with the monitored individual which is virtually impossible to achieve using sensing components (including Web cameras) installed in the home environment. It follows that home robots, alone or in combination with a limited set of sensors embedded in the home environment, have the potential to achieve effective monitoring of individuals in a rather unobtrusive way and with very limited likelihood of generating privacy concerns.

In summary, platforms combining home robots and wearable systems could be used in a variety of home-monitoring applications ranging from the detection of seizures in patients with epilepsy [64] to the detection of cardiac arrest in patients undergoing cardiac monitoring [65]. Emergency situations would be detected via online processing of data gathered by wearable sensors, and an alarm message would be sent to the home robot. The robot would wake up (if it is in standby mode at the time it receives the alarm message) and check upon the patient's condition. The system would provide high detection sensitivity without the drawback of requiring human intervention every time a false-positive detection occurs. Connected health software applications would further enhance the platform by assuring that qualified clinical personnel are promptly put in touch with the patient when he/she needs it the most, i.e., during an emergency situation. Therefore, this type of platform could have a significant impact on our ability to clinically manage long-term conditions associated with impairments and functional limitations that compromise the individuals' quality of life.

Conclusions

It is now more than 50 years since the time when clinical monitoring of individuals in the home and community settings was first envisioned. Until recently, technologies to enable such vision were lacking. However, wearable sensors and systems developed over the past decade have provided the tools to finally implement and deploy technology with the capabilities required by researchers in the field of patients' home monitoring. As discussed, potential applications of these technologies include the early diagnosis of diseases such as congestive heart failure, the prevention of chronic conditions such as diabetes, improved clinical management of neurodegenerative conditions such as Parkinson's disease, and the ability to promptly respond to emergency situations such as seizures in patients with epilepsy and cardiac arrest in subjects undergoing cardiovascular monitoring.

Current research efforts are now focused on the development of more complex systems for home monitoring of individuals with a variety of preclinical and clinical conditions. Recent research on the clinical assessment of wearable technology promises to deliver methodologies that are expected to lead to clinical adoption within the next five to ten years. In particular, combining home robots and wearable technology is likely to be a key step toward achieving the goal of effectively monitoring patients in the home. These efforts to merge home robots and wearable technology are expected to enable a new generation of complex systems with the ability to monitor subjects' status, facilitate the administration of interventions, and provide an invaluable tool to respond to emergency situations.

Acknowledgments

The author expresses his gratitude to his associates and collaborators for the discussions and collaborative work that originated this manuscript. Special thanks go to Fabrizio Cutolo, Anthony Dalton, Todd Hester, Richard Hughes, Chiara Mancinelli, Shyamal Patel, and Delsey Sherrill who worked on projects focused on wearable technology in the author's laboratory. Sincere thanks also go to Bryan Adams, Metin Akay, Harrry Asada, Danilo De Rossi, John Growdon, Holly Jimison, Nancy Huggins, Emil Jovanov, Rita Paradiso, Doug McClure, Misha Pavel, Marilyn Moy, Steve Schachter, Ludy Shih, Joel Stein, David Standaert, Alessandro Tognetti, Eric Wade, and Matt Welsh who collaborated with the author on projects related to the development and deployment of wearable technology. The author also expresses his appreciation to Patrick Kasi and Mel Meister for their technical support.

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About the Author

Paolo Bonato, Ph.D., serves as Director of the Motion Analysis Laboratory at Spaulding Rehabilitation Hospital, Boston MA. He is an Assistant Professor in the Department of Physical Medicine and Rehabilitation, Harvard Medical School, Boston MA, a member of the Affiliated Faculty of the Harvard–MIT Division of Health Sciences and Technology, Cambridge MA, an Adjunct Professor of Biomedical Engineering at the MGH Institute of Health Professions, Boston MA, and an Associate Faculty Member at the Wyss Institute for Biologically Inspired Engineering. He has held Adjunct Faculty positions at the University of Ireland Galway and the University of Melbourne. His research work is focused on the development of rehabilitation technologies with special emphasis on wearable systems and robotics. Dr. Bonato is the Founding and Current Editor-in-Chief of Journal on NeuroEngineering and Rehabilitation, an Associate Editor of the IEEE Journal of Biomedical and Health Informatics and the IEEE Journal of Translational Engineering in Health and Medicine. Dr. Bonato served as an Elected Member of the IEEE Engineering in Medicine and Biology Society (EMBS) AdCom (2007-2010), and as President of the International Society of Electrophysiology and Kinesiology (2008-2010). He served as Chair of the 33rd Annual International Conference of the IEEE EMBS (2011). Dr. Bonato served as Chair of the IEEE EMBS Technical Committee on Wearable Biomedical Sensors and Systems in 2008 and as founding member of this committee (2004-2012). Dr. Bonato is currently serving as IEEE EMBS Vice President for Publications (2013-present). He received the M.S. degree in electrical engineering from Politecnico di Torino, Turin, Italy in 1989 and the Ph.D. degree in biomedical engineering from Universita` di Roma "La Sapienza" in 1995. Dr. Bonato's work has received more than 3,500 citations (Google Scholar). To learn more about Dr. Bonato's work, visit http://srh-mal.net/.

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IEEE SOCIETY SPOTLIGHT

SIGNAL PROCESSING SOCIETY

IEEE offers more than 35 Societies that focus on technical information in specialized technology fields. Each issue of THE BRIDGE will feature an IEEE Society and include information on activities and information that can benefit IEEE-HKN members.

IEEE Signal Processing Society®

Traditionally, student membership and retention has been an area that consistently needs improvement throughout IEEE and IEEE societies. After all, IEEE is enormous – more than 350,000 members (over 50,000 of them students) worldwide with oceans, time zones, languages, and organizational units dividing them. Amassing and maintaining such a membership base is no easy task, and engaging each individual with due care is nearly impossible. That's why the IEEE Signal Processing Society (SPS) is seeking meaningful improvement, making strides to increase student services, and thus student involvement, engagement, and retention.

At the 2014 International Conference on Acoustics, Speech, and Signal Processing (ICASSP) in May, the SPS held its first annual Signal Processing Cup (SP Cup). The SP Cup is a student competition that allows teams of students and graduate students to work together to solve a real-world problem using signal processing methods and techniques. After all participating teams submit their projects, three teams are selected to present their work at ICASSP, where the winners are selected and prizes are awarded. The winning team takes home a $5,000 grand prize. The first and second runners-up receive $2,500 and $1,500, respectively. The SPS sponsors limited travel support for up to three members of each selected team. Learn more about participation and entry information for the SP Cup on the SPS website. Registration for the 2015 competition will soon open.

In a fast-paced field like signal processing, networking and developing meaningful professional relationships is especially critical to success. That's why, at ICASSP 2013, SPS successfully launched the first ICASSP Student Career Luncheon. Since then, more than 300 students and new graduates have met with representatives from over 20 companies including Google, Facebook, Apple and AT&T. Companies introduce students to job opportunities and even conduct on-site interviews and recruit attendees at the event. SPS plans to continue hosting the Student Career Luncheon during ICASSP, its flagship conference. More information, as well as details about ICASSP and other SPS conferences, is available online. Student Luncheon registration is open only to SPS student members.

Student and graduate student members are paving the future of engineering, so fostering their knowledge and their interest is vital to the advancement of life-changing technologies. Such technologies demand time, effort, and discipline, which is why the SPS offers Seasonal Schools in Signal Processing. These workshops are geared toward undergraduate and graduate students who seek to gain thorough insight and background in select signal processing topics. Seasonal Schools also offer students the opportunity to connect with practitioners and gain real-world experience through hands-on experiments and tutorials. This year's Seasonal Schools are projected to take place in Canada, Taiwan, Italy, and Romania.

This is only a sampling of student-oriented projects that the SPS is working on through next year. If you'd like to get involved with these or learn more about other SPS membership activities, please email Kenneth Lam, Director-Student Services or SPS Membership and Content Coordinator Jessica Perry.

CHAPTER NEWS

IEEE-HKN Members Gather in Iowa for 2014 Student Leadership Conference

In This March, more than 100 students, Faculty Advisers and the Board of Governors of IEEE-HKN attended the annual IEEE-HKN Student Leadership Conference. The Nu Chapter at Iowa State University hosted the event in Ames, Iowa.

The weekend included a variety of opportunities for personal and professional development, networking and fun.

Pictures from the event are available online. Videos and session presentations from the conference are available through the IEEE-HKN website at www.hkn.org.

Next year's event will be hosted by the Mu Chapter at the University of California, Berkeley. All IEEE-HKN members – students and alumni – are encouraged to participate and support the event. If you or someone or a company you know are interested in getting involved, contact IEEE-HKN Headquarters.

Group shot of the IEEE-HKN 2014 Student Leadership Conference attendees.

Event programming included an engineering challenge sponsored by Texas Instruments. Teams were tasked with solving a variety of engineering questions.

The host Conference Committee from the Nu Chapter at Iowa State University.

The winners of the icebreaker plus Conference Committee member Curtis Ullerich (right).

Attendees participate in one of nine breakout sessions.

SLC attendees participate in an icebreaker: using just masking tape and sheets of paper, create a bridge across two chairs that will hold more cans of soda than any of the other groups.

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IEEE-HKN UPDATES

IEEE Educational Activities Board members inducted into IEEE-HKN

Several members of the IEEE Educational Activities Board were inducted into IEEE-HKN during the February board series meetings. The induction recognized these volunteers' commitment to IEEE and the profession. Welcome to IEEE-HKN!

From left to right: EAB members Jon Rokne, Kristi Brooks, Ramalatha Marimuthu, Yatin Trivedi, Mike Lightner, Pamela Jones, Sorel Reisman and J. Kenneth Pigg.

Know a child destined for IEEE-HKN?

It's never too early to share your IEEE-HKN pride – email info@hkn.org to get a free baby bib for your child! Send a picture of your child wearing the IEEE-HKN baby bib and he or she may be included in a future issue of THE BRIDGE or included in IEEE-HKN social media content.

Ava Scarlett Kurzweg, future IEEE-HKN member. Submitted by Tim Kurzweg, IEEE-HKN Board of Governors.

Welcome, Lambda Sigma Chapter!

The newest Chapter of IEEE-HKN, Lambda Sigma, was installed at the University of California, Riverside, on 28 February. IEEE-HKN Board of Governors member S.K. Ramesh led the installation. Do you know college students or professors interested in starting an IEEE-HKN Chapter at their campus? Encourage them to reach out to IEEE-HKN Headquarters (at info@hkn.org) to start the process.

Members of the Lambda Sigma Chapter along with IEEE-HKN Board of Governors member S.K. Ramesh (red tie, center). Credit: Ilya Dumer

Chapter Annual Reports due 30 June

Don't forget to submit your Chapter's Annual Report to IEEE-HKN Headquarters by the deadline of 30 June. Filing this report is easy (using the online form at http://bit.ly/IEEEHKNchapterreport) yet critical for maintaining the historical records of your Chapter. Contact info@hkn.org if you have any questions about Annual Reports.

Save the Date: 28 October is Founders Day!

IEEE-HKN Founders Day

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MEMBER PROFILE

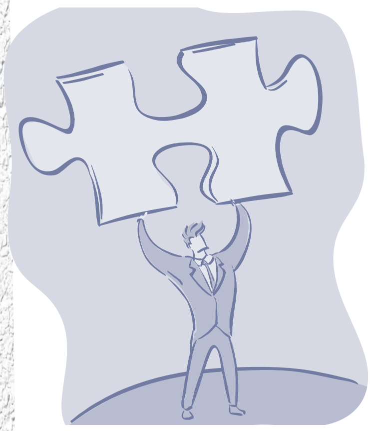
Cameron Pierce LaFollette *Nu Chapter*

Cameron Pierce LaFollette is an electrical engineering senior, maker, and musician. After working several years as a commercial maintenance technician, he decided to study engineering. After starting college at 25, he got involved with VR research that was presented at SEAMUS 2013, was elected as president of the Nu Chapter of IEEE-HKN, and led the 2014 IEEE-HKN national conference. He has built various projects such as a Tesla Coil, a working replica shoulder cannon from the movie "Predator," a VR DJ controller, and an automation controller for haunted houses. He has been contracted to design control systems for several art installations featuring light and sound. He is currently working on a system using blue-tooth enabled 9-axis sensors to control virtual instruments, audio workstations, and visual effects from the motions of a performer or dancer. In his down time Cameron can be found making music with Ableton, home brewing, or DJing Drum'n'Bass on vinyl. Cameron is also a member of a search and rescue team, Star1, where he is avid in the art of human tracking. He resides in Ames, IA with his wife Crystal and can be contacted on Google+.

Why did you choose to study the engineering field (or the particular field you are studying?

I chose engineering because of my maintenance background; my infatuation with Tesla's work led me to electrical engineering. My love for electronic music led me deeper into the electronics and computational facets as well as my minor in music technology. Finally, I became exposed to micro-controllers and saw what they are capable of, and what people are doing with them in the maker culture. After an internship with Texas Instruments MCU division, I was hooked and switched my focus to embedded systems and began to learn as much about computer engineering as I could.

What do you love about engineering?



I see it as a method to uncage the mind, much like training and practice for an artist. Where, I used to say, "I wish they would make a product that could do [blank]", now I do a little research and say "I'm going make a device or program that does [blank]." And, sometimes, I get paid to do just that!

It also allows me to be a better problem solver in daily life, do many of my own repairs, make purchases that are more informed on things like cars and technology, and if I ever have kids there won't be a math homework question I can't answer. As a kid, I loved puzzles, brainteasers, LEGOs and logic problems. With engineering, I can build a meaningful career and hobbies on those same ideas.

What don't you like about engineering?

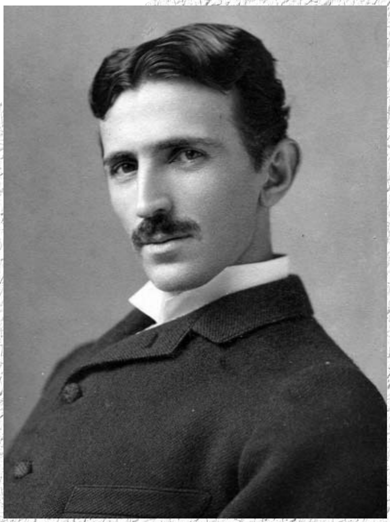
It's easy to get carried away. I think that there is a certain amount of obsessive-compulsiveness associated with engineering. Whether that's a requirement or a result of becoming a great engineer, I'm not sure. It's easy to become lost in the pursuit of perfection of a design in an area where it has little impact, or to try to explain every intricacy of a theory of operation to a non-technical friend and end up only annoying them in the process. It's important to not lose the big picture in the details.

What is your dream job?

To be part of a team that rapidly develops new and interesting devices: be those toys, consumer electronics, or one-of-a-kind gadgets. That's a big appeal that microcontrollers have for me, and why I'm a big fan of maker culture. If I could pair microcontrollers and rapid development together with augmented reality, that would be perfect. Or, alternatively, being a contributor to Make Magazine sounds pretty cool, too.

Whom do you admire, and why?

I admire anyone who has an idea and sees it to fruition against all odds. This applies to Elon Musk, who wanted to venture into the internet (Paypal), space (SpaceX), and renewable energy (Tesla Motors). It applies to every great scientist I can think of; Tesla, Maxwell, Einstein, the list goes on. But, it also applies to engineering students who were able stick with their courses when the going got tough and see that out to graduation and make an impact in the real world. I guess I've always liked the little guy who does big things.


Nikola Tesla

What direction do you think that the engineering field is headed in the next 10 years?

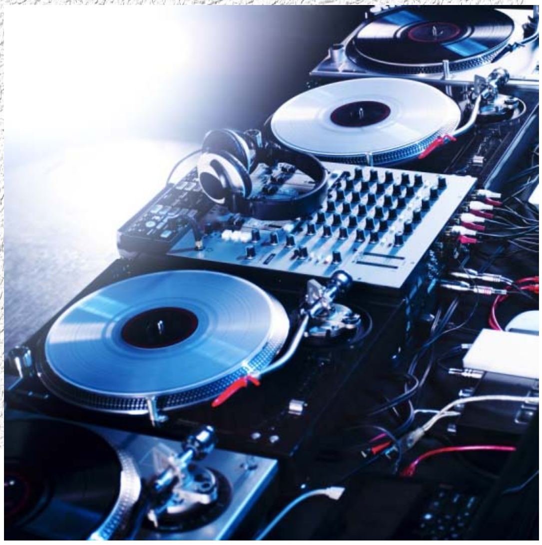
Nanotech and embedded systems. These two fields are dramatically changing the ways we look at things. On the nano side, we have new transistor technologies, quantum computing, metatronics and myriad of other applications emerging. Through embedded systems we are seeing smarter and more capable small devices and more robust augmented realities. Single-board microcontrollers such as Arduino, Texas Instruments MSP-430, Raspberry Pi, and Beagleboard have brought interfacing software and hardware into the mainstream, and the number of hobbyists doing these things is on the rise, which I think will drive the development of smarter microcontrollers.

What is the most important thing you have learned in school?

How to learn. There are so many new things out there to learn, and so many things that I will get rusty on or forget from school. This makes the ability to seek out information and self-teach it is invaluable. With that, there is nothing you can't do.

What advice would you give to other students entering college and considering studying your major?

Don't give up, don't run away, and do it at home. Sometimes when you're against the toughest problems, it's easy just to take a shortcut or skip it altogether, but these are opportunities to learn what it truly is to be a problem solver. This is where you learn how to learn. Also, you may take a class about something you really don't like, but one thing I've learned is that these subjects always seem to come back up. It's best to tackle these ideas and understand them early on, so you're ready for when it really counts. Lastly, make sure to take what you learn and apply it to a personal project. Nothing will teach you the ins and outs of applying a theory like burning up a project several times before finally, and victoriously, getting it right!



Finish this sentence: "If I had more time, I would…

……build more projects and create more music!"

MEMBER PROFILE

Andrew Sears *Gamma Theta*

Andrew Sears received his BS in Electrical Engineering from Missouri University of Science and Technology. While there he was Student Council President and received the HKN award for the top outstanding electrical engineering student in the USA in both his junior and senior years (Outstanding Junior Award, 1994; Alton B. Zerby and Carl T. Koerner Outstanding Student Award, 1995). He was also on the USA Today Academic All American Team and a Rhodes Scholar Finalist. He received his SM in Electrical Engineering and Computer Science, and in Technology and Policy at MIT. While at MIT, he co-founded the Internet Telecoms Consortium, a multidisciplinary research group on the social and business implications of the Internet. After MIT he did Internet consulting to companies including St. Paul Venture Capital and Sprint. In 2000, he founded and serves as the Executive Director of the Christian nonprofit, TechMission with the goal of using technology to serve the poor. In the past 10 years, TechMission has matched 72,533 volunteers through ChristianVolunteering.org and funded 511 full-time AmeriCorps members and interns. He is also the president of City Vision College, which is an online college providing Bachelor's degrees in Nonprofit Management, Addiction Studies, Urban Missions and a Masters in Technology and Ministry. He is currently working on his Doctorate with Bakke University. He lives with his wife, Heather, and two boys in Quincy, MA.

Why did you choose to study the engineering field?

I chose engineering because I was good at math, and I saw that the biggest driver of change in the world is technology. I believed that to make a difference in the world a good engineer needs to be fully fluent in the world of technology/engineering, but also fully aware of the needs of the world. That enables the engineer to be the bridge between the needs of the world and technology solutions. I am also very entrepreneurial, and I love the ability to use technology to start new initiatives.

What do you love about engineering?

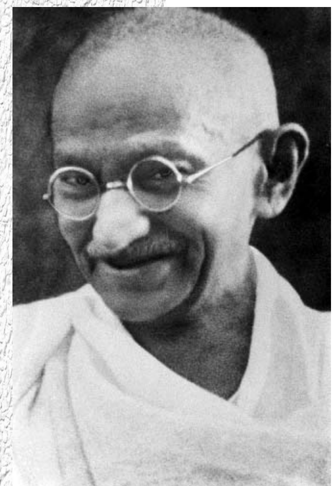
I love that technology gives us the ability to have greatly magnified impact on the world. Today, a few people can build something that can improve the lives of millions of people. I like that engineering uses logic and analysis, that it is marketable and has high-income potential. I like how it is data driven and promotes meritocracy.

What don't you like about engineering?

I wish that engineering as a discipline would focus more on the human impact of technology. I believe that an engineer is neither divorced from the end use of technology, nor not wholly responsible for its use. I meet engineers that have personal angst that they may be building technologies that are primarily used to kill people and in many cases in unjust ways. Another aspect that is difficult with engineering is that we are each such a small part in a much larger machine. Because of that, it is difficult to find the satisfaction of knowing exactly what you accomplished. Another part of this is that often engineers can create things that were intended for good, but ultimately end up causing a lot of harm (or vice-versa). I think the best we can do is to try our best to do things that make the world a better place, and if we realize that we are not doing that, then call a mistake a mistake and move on. If enough engineers do that, it will affect market forces that will benefit initiatives making the world better and slow those causing harm.

Whom do you admire, and why?

I primarily admire people who change the world for the better like Mother Theresa, Gandhi and Mandela. I also admire brilliant tech leaders who disrupt whole industries like Steve Jobs, Mark Zuckerberg and Bill Gates. I probably admire Bill Gates the most because he mastered the world of technology, but then realized that he could have a bigger impact on the world if he mobilized his resources to help the poor. At the end of our lives as engineers, I believe we should do work that we can say, I made the world a better place because the work I did as well as our personal impact on our families and communities outside of work .



Mahatma Gandhi

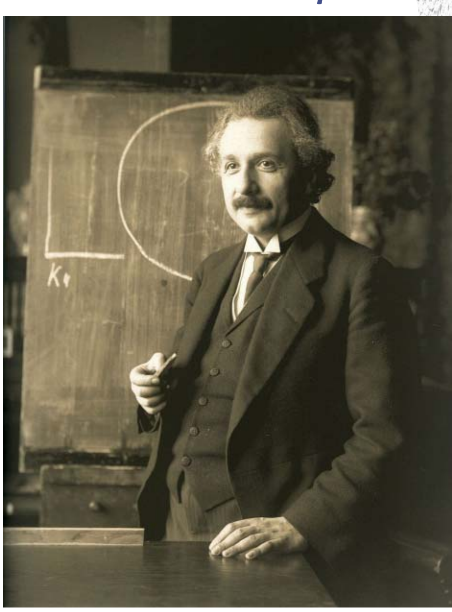
How has the engineering field changed since you started?

The dominance of the Internet has dramatically increased. This combined with the exponential effects of technology are causing the rate of change to dramatically increase. There is an increased need for entrepreneurs to be able to keep up with the dramatic increase in the rate of change. I think there is a growing consciousness of corporate social responsibility and ideas like the triple-bottom line, which measures the financial impact, social impact and environmental impact. Increasingly engineers will need to be aware of the impact of the complexity of all of these systems.

In what direction do you think that the engineering field is headed in the next 10 years?

I think that there will be both a continued growth in specialization which provides depth, but also increased demand for the breadth of interdisciplinary approaches. At Missouri Science and Technology, I got depth by studying Electrical Engineering, but I got by breadth in leadership through student activities. At MIT, I got depth through my Masters in Electrical Engineering and Computer Science, but I got breadth through my Masters in Technology and Policy. That experience has enabled me to found a faith-based nonprofit called TechMission, which is focused on using technology to help the poor. We recently launched an accredited Master's program in Technology and Ministry to focus on providing breadth to Christian engineers. This program is an interdisciplinary program to enable Christians to bridge their faith with engineering through classes like: Systems, Theology of Technology, Technology and the Poor and Social Entrepreneurship. It is basically for "engineers who want to change the world." I think that there is a growing need for programs like this which provide breadth to complement the depth of pure engineering programs.

What is the most important thing you have learned in the field?



Albert Einstein

The most important thing I've learned is summarized from Einstein's quote, "Everything that can be counted does not necessarily count; everything that counts cannot necessarily be counted." The most significant things in our lives like love, family, friendships and faith are things that are not quantifiable. Many of the things that are most easily counted like money, possessions and publications ultimately have very little correlation to happiness. I spent the first part of my life optimizing based on external factors like awards and visible achievements, but it was later that I realized I needed my work to have meaning to myself and others for me to be happy. I also learned the importance of education. Before college, I was working for $5/hour at Burger King. Six years of education later, my next job was paying me $200 per hour. Although I made $200/hour, I still lived like I had $5/hour, so I could save money to do the work I wanted to do. That enabled me to have a couple of years where I was starting a nonprofit and I didn't need to make money.

What advice would you give to recent graduates entering the field?

Surround yourself with a community of people who are going where you want to go. If you get a job that pays well lacks meaning to you, then be thrifty and save your money until you can afford to take a job that brings more meaning. That does not mean it needs to be in the nonprofit sector (like I chose) because other sectors are larger and will have bigger impact on the world. I spent many years working with hundreds of ministries to address the "digital divide," which is the gap between those who have access to technology and those who do not. What I learned from that was that Google's Android Operating system has done more to address the digital divide than all the nonprofits and governments in the world. The point is to try to do work that is enjoyable and meaningful to you and that impacts the world.

I've seen too many people who get into overwhelming debt and work at a job that they hate. The problem is that they continue to buy bigger houses, cars and other things until they have no other options. Science shows that after minimal basic needs are met, money is uncorrelated with happiness. The conclusion of this is to be thrifty so you can find more happiness through work, family, community and faith.

If you were not in the engineering field, what would you be doing?

The three core values of TechMission, the nonprofit I founded are Jesus, Justice and Technology. I believe those values define the call over my life. If I was not trained as an engineer or in the engineering field, I believe that I would find my way back to a career within those three values because that is at the core of who I am. As a Christian, the summary of the Bible is "Love God and Love others, nothing else matters." I believe that it one way or another I would have found a way to "Love God and Love others" using technology.

Finish this sentence: "If I had more time, I would…

…Rest more. Play more basketball. Spend more time with my wife and kids. Spend more time praying by the beach."

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Influencing Public Policy

By Russell T. Harrison

Question: What do you get when you cross a politician and an engineer?

Answer: Russ Lefevre!

Wait … what?

If you looked for two careers that were the least alike, engineering and politics would be near the top of the list. For example, engineers have to develop workable solutions to problems on specific deadlines. Politicians, well, do not.

And yet, we have plenty of examples of individuals who have excelled in both fields. Congressman Rush Holt (D-NJ), who is about to retire after sixteen years in Congress, was the Assistant Director of the Princeton Plasma Physics Laboratory before getting into politics. One of his Colleagues, Thomas Massie (R-KY), founded a successful software company before running for Congress in 2012. President Hoover was a successful and well regarded mining engineer before becoming President.

While it is not exactly common to find members of Congress with technical backgrounds, it is becoming less unusual as time goes on. For example, there are twenty medical doctors in the current Congress: seventeen Representatives and three Senators. This is up from sixteen in 2010.

It is about time. Policy debates in Congress are becoming increasingly technical and complicated. Issues like cybersecurity, internet governance, patent law and healthcare require an understanding of technology and science. The few engineers and scientists in Congress help provide some of the expertise necessary to understand these issues. But that is not enough. With 535 members of Congress, a few dozen members with background in a technical field cannot advise everyone.

A Legislative Success Story: The Noyce Scholarship

Which brings us back to Dr. Russ Lefevre. Dr. Lefevre had a distinguished career as a radar engineer where he helped develop the U.S. Navy's first airborne multi-mode radar. He also did cutting-edge work at the Technology Service Corporation on remote sensing technologies. He led a major effort to develop a commercial version of a dual frequency airborne Interferometric Synthetic Aperture Radar system to map the earth. He was an adjunct professor at the University of North Dakota for many years. Dr. Lefevre's long and distinguished career included a year as President of the IEEE-USA and the IEEE Aerospace and Electronic Systems Society. For these efforts, he was named a Fellow of the IEEE and the American Association for the Advancement of Science (AAAS)

Of course, you can find plenty of talented, dedicated engineers like Dr. Lefevre in the IEEE. But Dr. Lefevre did something very few people ever do: he created a new government scholarship program. I do not mean he thought up the idea for the scholarship – he did not. Rather, Dr. Lefevre worked from inside of Congress to craft the legal language that created the scholarship and then shepherded it through the legislative process so that it could become law.

In other words, Dr. Russ Lefevre has succeeded in both the engineering and policy worlds, making him a perfect cross between an engineer and a politician.

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Dr. Lefevre's story begins in 2001 when he was selected for one of IEEE-USA's prestigious Congressional Fellowships. The award allowed Dr. Lefevre to work for the U.S. Congress for one year as a full-time staff member of a member of Congress, in this case Sen. John Rockefeller from West Virginia. The Congressional Fellowship is one of three Fellowships IEEE-USA offered in 2001, two for Congress, one for the State Department. IEEE-USA has since added a fourth Fellowship at the U.S. Agency for International Development (USAID).

The details for each of these programs are similar. Fellows are paid an annual stipend by IEEE-USA for one year, but they spend that year working full time for a Member of Congress, the U.S. State Department or USAID. In other words, IEEE-USA pays them to provide technical advice to our government for one year. The Fellows gain invaluable insight into how our government functions, while the government gets their knowledge and technical expertise. It is one of the clear win-win propositions in Washington

(Just to be clear – even though IEEE-USA pays a stipend, Fellows have no obligations to IEEE-USA, and in fact rarely interact with IEEE-USA during their year of service.)

As Dr. Lefevre recalls, his work on the Robert Noyce Teacher Scholarship began on one of his first days as a member of Sen. Rockefeller's staff. Dr. Lefevre was at a reception to congratulate Congressman Sherry Boehlert (R-NY) on becoming Chair of the House Science Committee. At the time, Dr. Lefevre's boss was Chair of the Senate Science Committee, making the pair the most important voices on Capitol Hill on science policy.

After Dr. Lefevre introduced himself to the new Chair, Congressman Boehlert informed Dr. Lefevre that he and Sen. Rockefeller needed to reintroduce the Robert Noyce Teacher Scholarship Bill. Dr. Lefevre immediately agreed, and then later that evening figured out what the Noyce Scholarship was.

It turned out that, back in the mid-1990's, Sen. Rockefeller and Rep. Boehlert had come up with an idea for encouraging more engineers and scientists to become teachers. The idea was simple – in exchange for a scholarship from the National Science Foundation (NSF) to pay for their STEM (Science, Technology, Engineering and Math) degree, students would agree to teach science or math at a public school for two years for each year of scholarships they received. The program would help students get STEM degrees and improve pre-university science and math education: a clear win for the country.

But there was a problem. The NSF did not want to evaluate students for the program. The NSF believed, probably correctly, that it did not have the infrastructure in place to evaluate students, and the agency did not particularly want to build that infrastructure. This simply was not something the NSF felt was part of its mission. Congress could have forced the NSF to manage the program, but did not really want to. So, the idea was shelved.

Robert N. Noyce

Known as "the Mayor of Silicon Valley," Dr. Robert Norton Noyce is considered one of the creators of our modern computer-driven economy. Over his distinguished career, Dr. Noyce helped found both Fairchild Semiconductors and Intel. He also earned 16 patents. These include the integrated circuit (with Jack Kilby) and several additional foundational technologies upon which our modern economy is built.

See the IEEE Global History Network for their biography of Dr. Noyce (www.ieeeghn.org/wiki/index.php/Robert_Noyce). Also, the IEEE Robert N. Noyce Medal was established in his honor to recognize exceptional accomplishments in the microelectronics industry.

Robert N. Noyce Medal

In addition to his technical achievements, Dr. Noyce believed in the power of education. In particular, he believed that education, specifically STEM education, was vital for underprivileged children and was a key weapon against poverty. The Noyce Scholarship honors his commitment to education by helping improve pre-university STEM education in disadvantaged urban and rural school systems.

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Until, that is, Dr. Lefevre got a hold of it. Through a series of meetings (often very long meetings) with the NSF leadership, Dr. Lefevre and his colleague Barbara Pryor realized that while the NSF did not want to evaluate students, the agency already evaluated universities. And universities had plenty of experience evaluating students. So they reached a compromise. The NSF would evaluate education programs at universities. If the programs were good enough to qualify, the schools would then be allowed to offer a certain number of Noyce Scholarships, but the universities would be responsible for selecting the specific students to receive them. The NSF evaluates the universities, and the universities evaluate the students, allowing everyone to play to their strengths.

The solution was simple, easy to implement, and effective. Exactly the type of solution engineers like.

But Dr. Lefevre was not done yet. In Washington, coming up with a good solution to a problem is only part of the battle – and not the most difficult part. Now that they had a solution, it had to be passed into law.

That is not a simple thing. Democracies, and American Democracy especially, are designed not to get things done. That is, our system of government is designed to be inefficient. The Founding Fathers were concerned that if they gave the government too much power, they would also be giving it enough power to create a tyrant. Their elegant solution was to distribute power among as many people as they could, so that many people would have to agree before passing a new law. This makes our government very inefficient – but that inefficiency is actually a feature of the system, not a bug.

With support from Rep. Boehlert's Chief of Staff David Goldston, Dr. Lefevre was able to have his Noyce Scholarship added as an amendment to a bill to create a new Math and Science Partnership program. This larger bill included a number of provisions to promote STEM education. Dr. Lefevre also enlisted the support of two prominent Senators: Sen. Pat Roberts (R-KS) and Sen. Ted Kennedy (D-MA). In addition to being from different parties, these two Senators were recognized leaders in the Senate, especially on education issues.

In just a few months, Dr. Lefevre, a professional engineer with no formal training in public policy nor politics, had successfully brokered a compromise between a major federal agency, Congress and our nation's leading universities. He had attached his idea to legislation that was very popular in both parties, and signed up leading legislators from both parties as champions. The Robert Noyce Teacher Scholarship was well on its way to becoming real.

Then September 11, 2001 happened, and everything stopped.

In the end, it took another year for the Noyce Scholarship to become law. That is how Washington works sometimes – even the best prepared plans can get delayed by unexpected events. But once Congress was able to focus again on STEM education, Dr. Lefevre's work paid off, even though he had left Capitol Hill by then. The Robert Noyce Teacher Scholarship program was part of the National Science Foundation Reauthorization bill of 2002 and has itself been reauthorized twice since. The program is widely considered a successful and useful government program.

The IEEE-USA and Public Policy

So what does this have to do with you?

Dr. Lefevre's story illustrates something that is becoming increasingly clear: engineers have an important role to play in the policy world. Most engineers think, if they think about the policy world at all, that their contributions to the policy world should consist of them telling politicians about technology. And that should certainly be part of IEEE members' role – but not all of it.

The Noyce Scholarship shows that engineers have more to offer our political system than just information. Engineering is not a set of facts, like History. It is also a way of thinking and a way of solving problems. In particular, engineers are taught how to build and analyze systems, complex series of machines, events or actions to make them all work more efficiently.

Engineers are good at pulling systems apart, figuring out what each piece does, and then putting an improved system back together. It should not be a surprise that engineers have made important contributions in energy, education, financial, and dozens of other policy areas. The world is very complex, and it takes someone comfortable with complexity to make sense out of it.

In the case of the Noyce Scholarship, the program could not get off the ground until someone saw how the NSF, universities, and this new program could fit together. Congress tried, but the NSF did not have the expertise necessary to fill the role Congress wanted it to fill. This impasse lasted for almost a decade. It took an engineer to realize that, by adding universities to the program, the Noyce Scholarship could use one of the NSF's preexisting strengths. And this realization allowed the system to work. In fact, once Dr. Lefevre realized how to fit the pieces together, it took less than two years to create the program in law – a long blink by Washington standards.

Once engineers decide they want to help policy makers, they immediately encounter a second problem: how?

In a perfect world, politicians would reach-out to engineers for advice on issues that require a technical understanding. But this is not a perfect world. Politicians at all levels, especially members of Congress, are constantly besieged by people with opinions on what the politicians should be doing. Just making sense of the current noise is hard enough. Few have time to go out and find people with additional advice on what to do.

So engineers need to proactively engage politicians on the politician's turf. Dr. Lefevre did this by becoming an IEEE-USA Congressional Fellow. He, technically, became a Congressional staffer for a year, giving him plenty of opportunities to influence Congress. If you are interested in learning more about this program, I encourage you to visit the Fellow's homepage at http://www.ieeeusa.org/policy/govfel

However, interacting with Congress does not necessarily require a year of your life, nor does it require moving to Washington, D.C. There are plenty of ways IEEE members can be heard without taking such dramatic steps.

For example, in 2011 Eastern Kansas elected a new member of Congress, Kevin Yoder (R-KS). Before becoming a Congressman, Mr. Yoder was Chair of the Kansas State Agriculture Committee. Before that, he was a rancher. In other words, Congressman Yoder did not know much about engineers or engineering. This is not unusual, nor is it necessarily a problem.

Still, IEEE member Cale Yates, former Chair of the IEEE Kansas City Section, thought IEEE members and the new Congressman Yoder should introduce themselves. To do this, Mr. Yates invited Congressman Yoder to breakfast. And he came.

One Saturday morning in June, 2011 the Kansas side of the Kansas City Section (the section extends into Missouri) met at a hotel outside of Kansas City. Their guest for the meeting was Congressman Yoder. The Congressman spoke for thirty minutes or so about what his priorities were in Congress, what his office was working on, and what he thought needed to be done in Washington. Then the thirty-five or so IEEE members in the room asked questions and discussed whatever they wanted to for the next thirty minutes.

Most of the questions focused on support for federal research, job creation, or the economy. But one question in particular stood out.

Towards the end of the meeting, an IEEE member asked if the Congressman supported efforts to make it easier for graduates of American universities to immigrate to the U.S. after earning their degrees. The Congressman admitted that he had not thought about it, but said it seemed like a good idea. The IEEE member, a professor at a near-by university, explained how much immigrants have contributed to our high-tech economy, and how talented some of her students where. Why are we not letting them stay?

Apparently, the Congressman agreed. In October of 2011 Rep. Raul Labrador (R-ID) introduced a bill in Congress that would have given every international STEM graduate student in the United States a green card within a year of graduating. Rep. Kevin Yoder was one of five other legislators who signed on as an original cosponsors of the bill.

This bill (The American Innovation and Education Act of 2011, H.R. 3146) represented a watershed moment in the high-skill immigration debate. Prior to that bill being introduced, most people in Washington thought that immigration reform was impossible. After, reform seemed quite possible. In fact, Rep. Labrador's bill passed the House in late 2012, although the Senate failed to vote on it. Provisions from H.R. 3146 were included in the comprehensive immigration reform bill passed by the Senate in 2013.

And it all started with one question from one IEEE meeting at a breakfast held for a Congressman who did not know much about engineers.

Engineers have plenty of opportunities to interact with their legislators. IEEE-USA runs several events a year in Washington where IEEE members, including students, can come in for meetings with their members of Congress.

Representative Kevin Yoder addresses the IEEE Kansas City Section.

Dozens of local sections across the country have hosted successful meetings with legislators, much like Kansas City did. Other sections have held meetings at their legislators' local offices.

Engineers can also call or write to their members of Congress. While old-fashioned, these tactics do still work – with the important caveat that you cannot write actual letters to Congress anymore. For security reasons (anthrax mailed to Congress in 2001 killed five people), Congress does not like getting paper mail these days. Send e-mail or faxes instead.

What is important is not how engineers communicate with legislators. All that is necessary is that engineers do communicate with legislators. It is important to our society, and in fact any society, that people with an understanding of technology and an ability to understand systems help politicians govern. You have an important role to play, but nobody is going to come ask you to play it. You have to take the initiative. But when you do, as Cale Yates and Russ Lefevre learned, great things can happen.

But wait! What if you are a student? You are not qualified as an engineer yet. You do not have a degree and many students at American universities are not even Americans (yet). Surely, it is too early for you to get involved, right?

Nonsense. First, engineering students know more about technology and systems than most members of Congress or their staffs, so you clearly have ideas and insights to contribute. Second, engineering students are among the most economically valuable students at any university. Legislators who represent those universities would very much like you to stay in their districts or states after you graduate. Those legislators are very interested in your future plans, and so will be very interested in what you have to say.

Third, most Congressional staffers are in their mid to late twenties, and state legislative staff are even younger, so they are in your peer group. They may relate to you better than one of your colleagues with twenty years of experience.

Students at the University of Illinois found this out in late March of 2014. Eight students, led by IEEE member Gloria See, joined IEEE-USA and thirty other IEEE members for our annual Congressional Visits Day. The students met with six members of Congress and their staff on March 26th to discuss the federal budget. Their meetings were all successful, which makes sense. Who better can discuss the value of federal support for STEM education and our research universities than current engineering students?

The key here is not how old you are, nor what type of credentials you have, nor even where you are from. The key is to speak up. Democratic governments are designed to listen to voters – but voters have to take the initiative whether in the United States or other elsewhere.

IEEE-USA is located in Washington, DC to help IEEE members in the United States work with our national government. We encourage all IEEE members, regardless of where you live or what field you are in, to make an effort to communicate with policy makers. Our staff is here to help in any way we can.

So who wants to step up?

For Further Information

IEEE and other professional societies offer opportunities for members, including students, to participate in public policy activities. The resources below provide additional information on such opportunities and on the topics in this article.

- IEEE-USA Public Policy Resources, www.ieeeusa.org/policy
- IEEE-USA Government Public Policy Fellowships, www.ieeeusa.org/policy/govfel/
- Washington Internships for Students of Engineering (WISE), www.wise-intern.org
- American Association for the Advancement of Science (AAAS) Public Policy Fellowships and Mass Media (Student) Fellowships, www.aaas.org/page/fellowships
- Robert Noyce Teacher Scholarship Program, http://nsfnoyce.org/

About the Author

Russell T. Harrison is IEEE-USA's Director of Government Relations and has served in other policy-related positions in IEEE-USA. Prior to joining IEEE-USA in March 2003, Harrison directed grassroots programs and served as a professional lobbyist at the Institute of Scrap Recycling Industries and the American Iron and Steel Institute. Harrison has a bachelor of arts degree in political science, with minors in history and communication arts, from Allegheny College in Meadville, PA and received a master's in public policy from the University of Maryland. Harrison earned a certified association executive (CAE) professional certificate.

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