Technology Beyond Tomorrow

Technology Time Machine 2018
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San Diego, California

November 2018

IEEE Future Directions recently hosted a successful Technology Time Machine symposium (TTM 2018) on October 31 and November 1, 2018 in San Diego, California, focusing on the theme of technologies *Beyond Tomorrow*. The room was abuzz as panelists engaged the audience with topics including:

- an intelligent ambient that customizes the environment to each person
- the future role of human digital twins and their legal and ethical implications
- smart materials that will significantly address energy efficiency
- development of a prosthetic for long-term memory
- brain computer interfaces to help enable the disabled through invasive and non-invasive measures
- applying artificial intelligence to the food supply chain
- blockchain for management of food safety and decreasing food waste
- current and future augmented and virtual reality (AR/VR) hardware and its applications

While these topics seem diverse, synergies and natural interdependence between the various technologies and their potential applications were evident through the panel discussions and further conversation that occurred among the attendees. A broad understanding of future technologies enables engineers to design their innovations to capture and leverage the commonalities that may exist.

The ethical impact of technology was addressed throughout the conference. Given the future advancement of technology and its impact on all humans, it is critical for engineers to consider ethical and social concerns throughout a product's entire lifecycle, from original idea through design and implementation, to insure that decisions are made with both technology and societal impacts in mind.

An introduction to a revolution based on the fusion of physical, digital, and biological elements was presented by the **Day 1 keynote speakers** Katalin Bartfai-Walcott and Jeff Fedders of Intel. Their presentation, titled "I Am Aware…", focused on the ambient technology era to come which is the convergence of the rules-based technology world and the human world driven by behavior and biology. It is supported by a blending of the traditional and digital business models, creating a transactional marketplace between ambient and human objects. Ambient technology is already being investigated in smart cities, autonomous vehicles, energy distribution and other applications. According to Bartfai-Walcott, "Ambient creates a new environment to provide a consistent and trust immersive experience without mindfulness of the complex underlying computing which enables the interaction."

"Ambient is a paradigm shift."
- Katalin Bartfai-Walcott, Intel

Watch the Bartfai-Walcott and Fedders keynote presentation at IEEE.tv.

The panel on **Women Making the Future** included Alicia Abella of AT&T who was the moderator, Katalin Bartfai-Walcott of Intel, Mary Gendron of Qualcomm, Christine Miyachi of Xerox, and Jeewika Ranaweera of Oracle who represent many diverse backgrounds and expertise. They discussed various implications of technology including the future of AI, its pros and cons, biases, and its impact on social relationships, jobs, and mental health. Overall, innovation and applications should drive technology while considering the responsibility to society with life-impacting technological developments. Young women have growing opportunities to have an impact on this world through engineering and should consider gaining not only STEM (Science, Technology, Engineering, and Math) expertise, but also creative thinking, communications, negotiation and management skills to be most effective in implementing the engineering technologies of tomorrow.

"You can't say 'Hello World' without it."
- Alicia Abella, AT&T

What's in our far future? Smart Materials, Brain Prosthetics, Augmented Humans, and Digital Twins, according to the **Far Futures** panelists, Roberto Saracco of EIT Digital, Ted Berger of University of Southern California, Cyber-Physical Systems R&D and Deployment expert Karin Hollerbach, and Conrad Rosenbrock of Brigham Young University. To tackle the energy needs of the future, Rosenbrock is applying state-of-the-art artificial intelligence to discover new super materials by exploring the vast space of elemental combinations using quantum computing. Bringing these new super materials to light may help build a stronger economy, a cleaner planet and improvements to the lifestyles and wellbeing of humanity. To support our longer lives, Berger spoke of a brain prosthetic that will allow patients with diminished long-term memory (due to dementia, stroke or other ailments) to utilize a brain computer interface and processing to regain memory. Electrodes connected to the hippocampus would extract a code representing a short term memory, processing will translate these codes into long-term memory codes, and electrodes will output those codes back into the hippocampus to be stored in long-term memory as usual. According to Saracco, the augmentation of humans will generate symbioses with machines that will establish emergent intelligence and capabilities creating applications and ethical considerations that will need to be researched. Impacting technological systems and augmenting humans requires investigation into implementation issues - particularly regarding controlling the potential system of systems. If a human is but one part of a system of systems, who controls the larger system?

In synergy with far future technologies, the **Neuroscience and Brain** panel consisting of Paul Sajda of Columbia University, Matthew Angle of Paradromics, Christoph Guger of g.tec, and Laura Specker Sullivan of the College of Charleston presented invasive and non-invasive brain machine interfaces (BMI) of the future as well as the ethical considerations of these technologies. Angle's research indicates invasive BMIs using micro wires on implants can be used in the near future to relieve patients' inabilities to connect to the outside world, such as deafness or blindness and later to treat other diseases such as Parkinson's, schizophrenia, bipolar disorder, phobias, anxiety and other mental disorders. In the far future, brain implants could be designed to read our thoughts to provide non-graphical, non-verbal user interfaces - touching and manipulating virtual controls such as a car radio with only our mind. Using non-invasive technologies has allowed Guger to aid in stroke rehabilitation, therapy that allows improved motor functions years after a stroke. Future applications of the

"If your society is telling you what you are doing is okay, how do you know it is not?
- Laura Specker Sullivan, College of Charleston

non-invasive BMI include possible communications with persons in a vegetative state or an embodiment station, which reads electrical brain signals and other physiological signals from participants and translates these signals into movement of a robot or avatar. Finally, Specker Sullivan addressed the many ethical issues associated with any brain manipulation and technology in general, including privacy and consent, identity and agency, augmentation, and bias. Engineers have an obligation to consider what type of society is desired and how to enable it through technology, continually investigating the possible ethical implications. There is a need to connect engineers with experts in the humanities (anthropologist, sociologist, ethicists, historians) to identify a systematic method of identifying ethical impacts of technologies.

Applications of technology applied to our food systems currently available and in development for the future identify opportunities for varying solutions, both simple and extremely high-tech utilizing AI, deep learning, sensors, and IoT. These applications were presented by the TTM **Agricultural Food Systems** experts, Derek Footer of HardTech Labs, Miku Jha of Agshift, Bernie Meyerson of IBM, John Verboncouer of Michigan State University, and IEEE TTM Committee Member Upkar Dhaliwal. Technologies applied to the food supply include:

- Cameras installed on the equipment that sprays herbicide. The cameras view the field to ascertain weeds which triggers the equipment to turn on the sprayer, eliminating the need to continually spray the entire field with chemicals. This provides cost savings in chemical use, improved yield, and healthier crops.
- In Brazil, cattle are branded with devices that measure anomalies in the cattle blood which are analyzed to determine if this herd needs to be injected with antibiotics.
- Utilizing defect detection, deep learning and AI to provide quality assurance in the food supply chain to facilitate objective, consistent and standardized quality assessment.
- A company in Vietnam wanting to identify the source of food items originally implemented a blockchain solution, but found it unwieldy and too complicated for their need. They are currently maintaining a database to identify provenance and certification of the source.
- Utilizing blockchain to identify the source of food throughout the entire food supply chain to improve food safety. Walmart and IBM experimented to identify the source of a mango chosen at random from a Walmart shelf and to identity all of the mangoes that were received with this mango. In the current method, this information would require 6 or more days; with blockchain technology, this time is reduced to 2.2 seconds. This enables better food safety, reduced time on the shelf in the case of a food contamination, and less food waste.

The goals of these technologies are to advance our food systems through reduction in the use of chemicals, decreased costs, waste minimization, profit maximization, improvement in health of crops, and long-term process improvement to address current farming inefficiencies.

The **Day 2 keynote speaker**, Poppy Crum of Dolby Laboratories, provided a fascinating look of the many ways physiological cues partnered with sensors and other technologies can allow our environment or devices to know more about ourselves than we do. Technology neuroplasticity will make us faster, hear more sharply, and think more effectively. Empathic technology will transform the relationships we have with each other and with the spaces

where we work, train, and live. Customized technology that knows our specific characteristics will be prevalent and will address our needs before we even realize the need.

What will the reality of the future be? **Mixed Reality** experts Jason Kenagy of Good Robot Labs, Nicholas Napp of Xmark Labs, Conor Russomanno of Meta, and IEEE Digital Reality Co-chair Raj Tiwari weighed in on the AR/VR/XR world of today and tomorrow. Challenges of current AR/VR technology such as device size and usability, power required, heat generated, optics limitations, effective haptics, realistic user interaction with objects, and safety and privacy issues, will be addressed through the intersection and implementation of multiple technologies, including Artificial Intelligence, Big Data, Blockchain, next generation networking and communications, Fog and Edge computing, and biosensing. A radically different future reality will be achievable when physiological inputs combined with sensing and multimodal brain computer interfaces allow non-perceptible immersive experiences.

TTM 2018 wrapped up with a panel of **Distinguished Experts** including Celia Desmond of Echologics and World Class Telecommunications, Jaafar Elmirghani of University of Leeds, Jeff Fedders of Intel, IEEE Digital Reality Initiative Co-chair Raj Tiwari, Steve Welby of IEEE, and Sean White of Mozilla. The experts agreed that the technology job environment is changing, and several ideas were presented to effectively adapt to these changes:

- Engineering designs are increasingly complex due to the interdependence of technologies, requiring engineers to have a broad understanding of multidisciplinary technologies and solutions and teams to effectively communicate and integrate the individual expert details and nuances.
- The complexity of the design process can be eased through the use of progressive refinement utilizing simulators to increasingly pinpoint the optimal solution. Throughout the process trade off considerations can be simulated to determine impact.
- The future of engineering will remain creative with repetitive tasks in the design process being performed by machine learning processes.
- Open source models will be utilized to benefit both industry and academia, especially when the problem being addressed is bigger than something individually solvable.
- Life-long training including experiential learning should be pursued continually in order to remain relevant in the fast pace change of technology and implementations.

"The pace of change has never been faster than it is today; the pace of change will never be as slow as it is today."
- Steve Welby, IEEE

TTM 2018 provided attendees with a deep dive into a broad set of technologies sprinkled with advice on career planning and success. The rapid pace of technology evolution, particularly those changing the way people communicate and interact with their environment, are highlighting the increasing impacts on ethical and societal considerations. IEEE should continue its role as a technical steward continually considering the impact on humanity.

Stay tuned for a "Vision of the Future" paper describing a deeper view of the future of technologies discussed at TTM 2018 as well as IEEE.tv recordings of the event, both of which will be published on the TTM portal. Follow TTM on Twitter, Facebook, and LinkedIn.