Engineering as a Force for the Public Good

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UC San Diego: World-Class University

Engineering as a Force for the Public Good

- **We Are:**
  - Student-centered
  - Research-focused
  - Service-oriented
  - Public university

- **One of the top 15 research universities worldwide.**
- **#7 Among Engineering Schools in the U.S.**
  - U.S. News ranking of Best Global Universities, 2014
- **Largest Engineering School in California**

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Initiatives with Campus Partners

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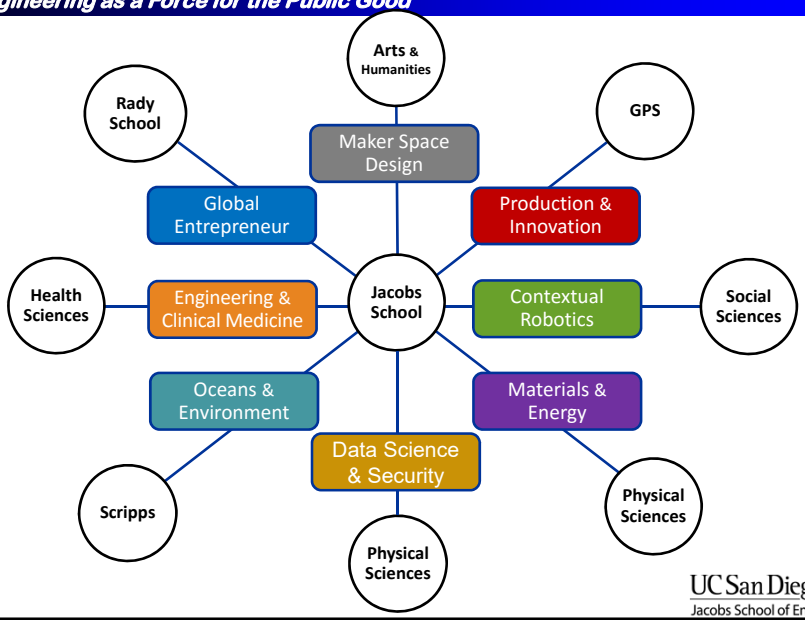

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Introduction to Abundance*

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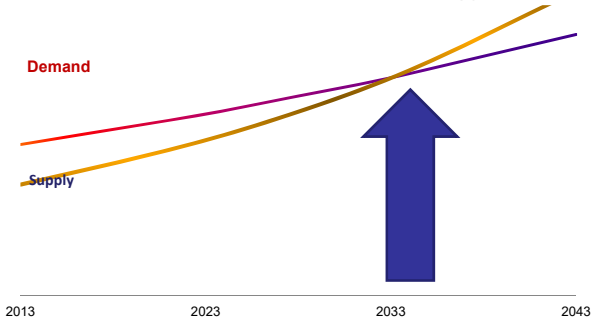
- **Abundance* movement forecasts an elimination in one generation (20 to 30 years) of major global problems:**

Food **Medical Care**

Clean Water & Air **Energy**



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* http://www.abundancethebook.com/

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Abundance* Enablers

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Exponential Technologies that Promise to Grow Into Large Markets Quickly

- Biotechnology and bioinformatics
- Medicine
- Nanomaterials and nanotechnology
- Networks and sensors (45 trillion networked sensors in 20 years)
- Digital manufacturing (3D printing) and infinite computing
- Computational systems
- Artificial intelligence
- Robotics

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* http://www.abundancethebook.com/

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Bill Gates: No Poor Countries by 2035

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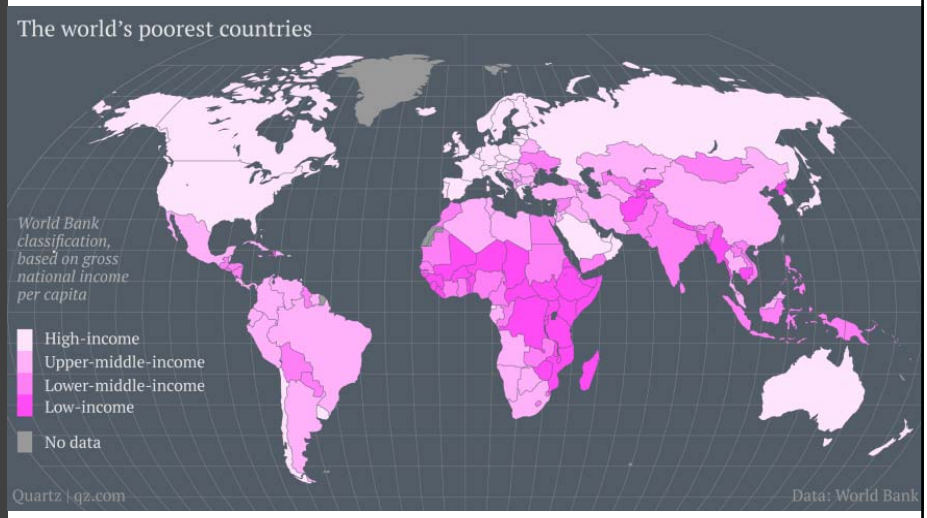

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http://qz.com/168341/bill-gates-predicts-there-will-be-almost-no-poor-countries-by-2035/

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Engineering for the Public Good

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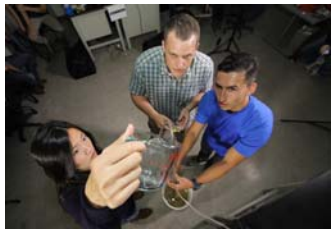
Medical Advances

Sustainable Energy Technologies

Transportation Safety



Solutions for Developing World

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Elastic Epidermal Electronics

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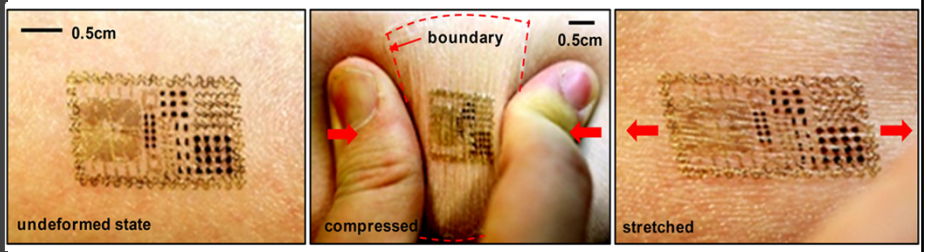

Professor Todd P. Coleman, Bioengineering

Science, Aug 12, 2011

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UCSD Center for Perinatal Health

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Unobstructive Monitoring

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Lifespan Home Care Technologies

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Center for Mobile Health Systems and Applications

Prototype, develop and evaluate technologies that support home care across the lifespan in a user-centered way

- Reduce hospital re-admissions
- Promote successful aging
- Smart-home technologies that anticipate health problems
- Supporting care-givers of patients with chronic, debilitating disease
- Reducing costs of medical care

iem
Institute of Engineering in Medicine

Center for Wearable Sensors

UC San Diego
HEALTH SCIENCES

The Design Lab
Think. Observe. Make.

QUALCOMM INSTITUTE

CW PHS
CENTER FOR WIRELESS & POPULATION HEALTH SYSTEMS

10

Wireless Sensing and Diagnostics

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Center for Mobile Health Systems and Applications

- Sensing and measurement of air, water, soil and food quality
- Track infectious diseases and sequelae
- Inexpensive diagnostics using mobile phones
- Technologies for healthcare in remote settings
- Data-driven approaches to disease surveillance and population health

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Whole Body Wearable Sensors

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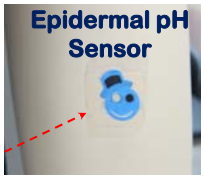
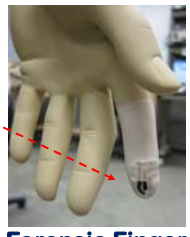
Fitness Textile Sensor

Metabolite Sensor with Electronics

Epidermal pH Sensor





Forensic Finger Sensor

Any-place, all-day, non-invasive monitoring directly on the skin or textile

Reducing health-care costs and enhancing the quality of life

Head to toe

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Non-Invasive Monitoring

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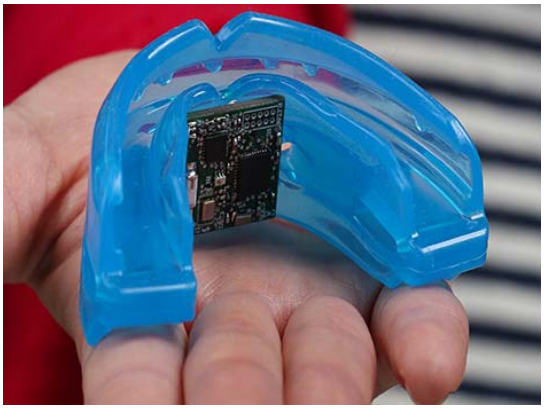

Non-Invasive Monitoring of Glucose and Saliva Biomarkers

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Flexible Electronics

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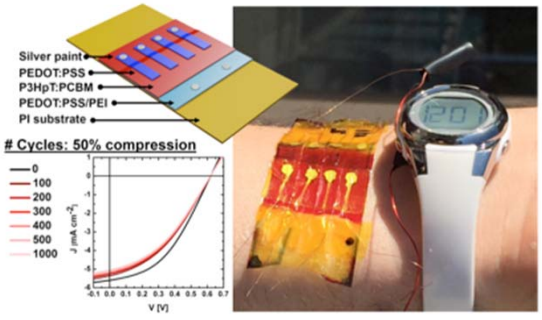
A future in which organic electronics and biological tissue can interact seamlessly



Flexible organic solar cells

- Molecularly stretchable electronics
- Whole devices that can degrade under physiological conditions
- Conjugated polymers capable of self-healing

Professor Darren Lipomi, NanoEngineering

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Harvesting Energy from Skin

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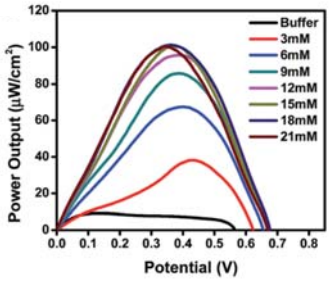
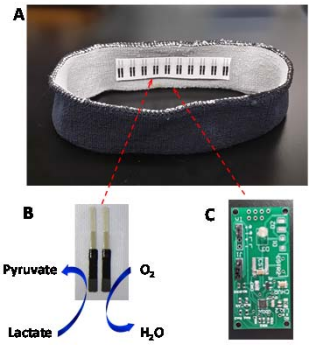
Watch "OFF"

Watch "ON"





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Printable Nanoelectronics

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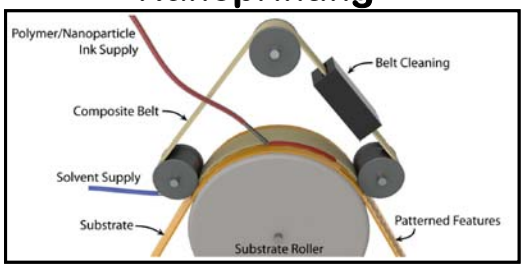
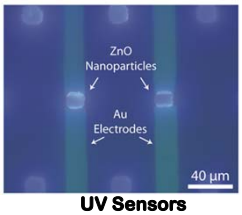
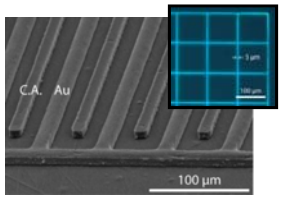
Nanoprinting



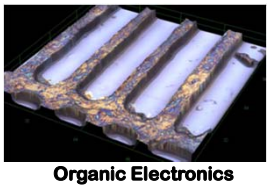
Several Applications



UV Sensors



Biosensors



Organic Electronics

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E. Erdem, et al., Small, 2013. M. Demko, et al., ACS Nano, 2012

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Precision Delivery of Drugs

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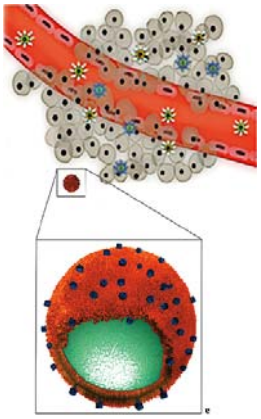

Targeted Combinatorial Drug Delivery for Cancer Therapy and Beyond

Loading of multiple drugs in desired proportions onto a nanocarrier. Next, nanocarrier is delivered to the cell of interest.

Antimicrobial Drug Delivery

Delivery of antimicrobial drugs to kill bacteria, fungi and viruses that can't otherwise be safely and effectively delivered

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Professor Liangfang Zhang, Nanoengineering

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Manufacturing Drugs in the Body

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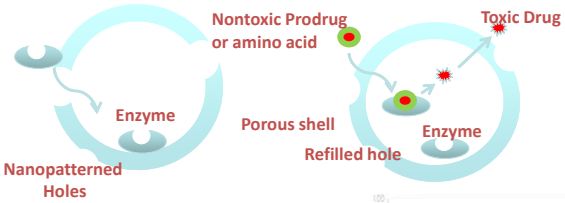
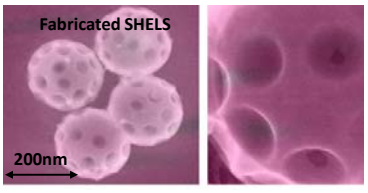
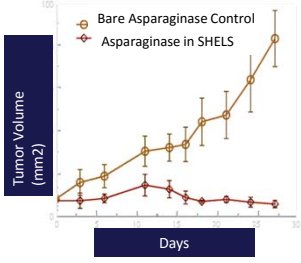
Syn Hollow Enzyme-Loaded nanoShell

Inanc Ortac and Sadik Esener (NanoEngineering & MCC)







Nano Letters January 2014

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In Vivo Proof of concept: Pancreatic tumor cannot grow when IM injected, asparaginase loaded SHELS distant from tumor depletes serum asparagine

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Sustainable Energy Technologies

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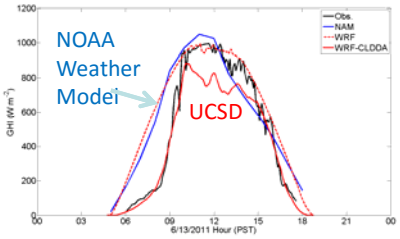
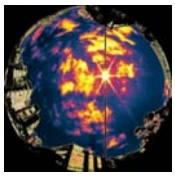
Professor Jan Kleissl, Mechanical & Aerospace Engineering



Solar forecasting research enables the power grid to accommodate more solar power.



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Computational Mechanics

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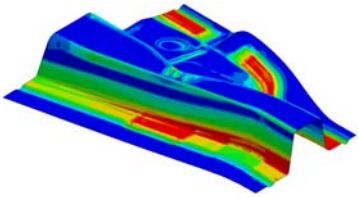
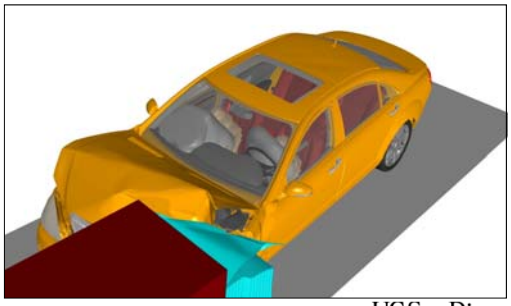
Single Surface Contact Algorithm for Crash Simulation

Professor David Benson, Structural Engineering



This research is used in all commercial codes to design cars to meet government crashworthiness standards worldwide.

Component manufacturing simulation



Final product performance

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Composite Structures Aviation Safety

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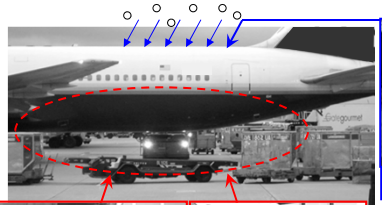
Professor Hyonny Kim, Structural Engineering

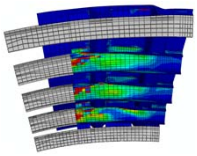
Investigation focused on *non-visible damage formation* in modern carbon-fiber composite aircraft structures.

Challenge: ***blunt impact threats*** creating internal damage ***showing little or no exterior visibility***



Hail Ice Impact

Ground Vehicles & Equipment Contact



Research Outcomes:
→ *improved safety*

- new model-prediction capabilities
- damage modes observation and awareness
- damage detection via robust sensor system

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Advanced, Multifunctional Materials

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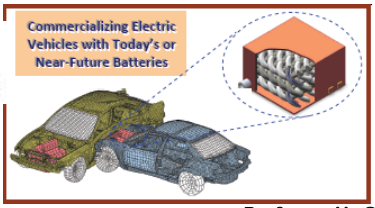
Multifunctional Materials Research Lab (MMRL)

To the Moon and the Mars:

"Lunar cement" and "Martian cement" Based on Lunar/Martian Soils

Advanced, Multifunctional Structural Materials

Commercializing Electric Vehicles with Today's or Near-Future Batteries



From the Earth:

- Protective Materials for Military and Sports, e.g. Next-Generation Humvee Floor & Mat to mitigate roadside bombs
- Next-generation electric vehicles (EV) using today's or near-future batteries – robust & multifunctional battery systems

Professor Yu Qiao, Structural Engineering

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CitiSense: Air Quality via the Crowd

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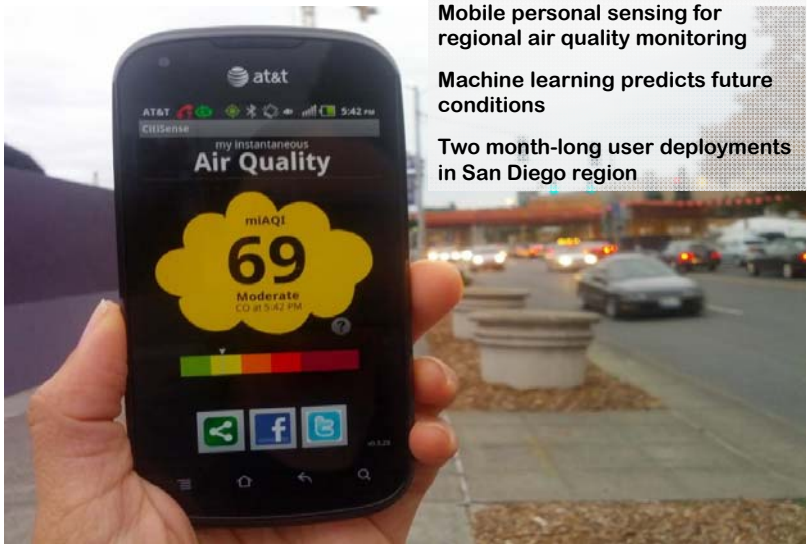

- Mobile personal sensing for regional air quality monitoring
- Machine learning predicts future conditions
- Two month-long user deployments in San Diego region

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Griswold, Dasgupta, Krueger, Rosing (CSE), Patrick (SOM)

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CitiSense

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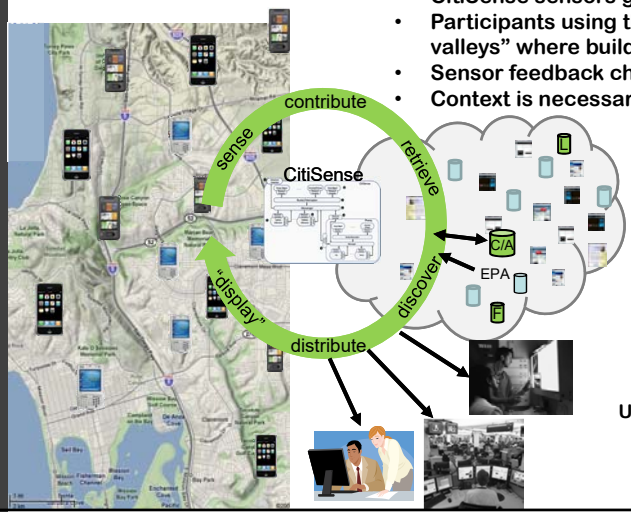
Changing user behavior with intelligent sensor feedback

- CitiSense sensors given to commuters
- Participants using the sensors found "urban valleys" where buildings trapped pollution
- Sensor feedback changed user behavior
- Context is necessary to achieve results



UCSD's NSF CitiSense Project

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Context-awareness in Urban Sensing

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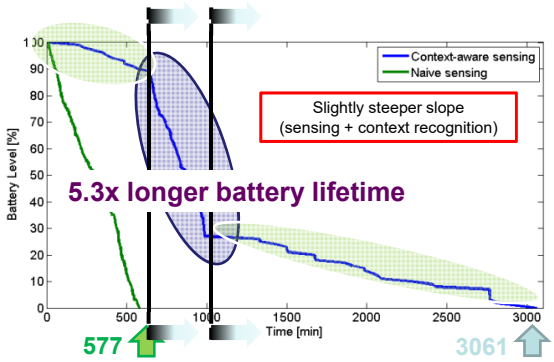

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Context-awareness in Smart Grid

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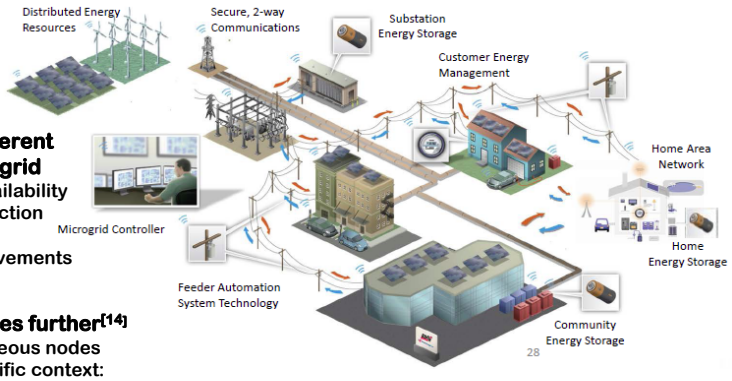

- **Context is inherent in the energy grid**
  - Source availability
  - Load prediction
  - Pricing
  - People movements
- **Smart grid goes further[14]**
  - Heterogeneous nodes
  - Node-specific context:
    - e.g. energy use, load flexibility, energy limits
  - Improved prediction
  - Improved stability – better matching of loads and sources limits frequency deviation
- **Our initial focus is on context-aware residential energy management**

[14] National Institute of Standards and Technology. www.nist.gov

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Distributed Control

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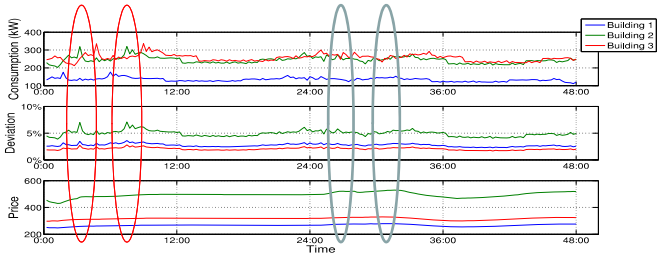
Swarm of Buildings Connected to a Smart Grid



- Swarm of smart buildings connected to the grid
- Each building has its own controller -> distributed control
- Smart grid reacts with pricing and stability signals
- Enables a study of system stability

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B. Aksanli, A.S. Akyurek, M. Behl, M. Clark, A. Donze, P. Dutta, Patrick Lazik, M. Maasoumy, R. Mangharam, T.X. Nghiem, V.Raman, A. Rowe, A. Sangiovanni-Vincentelli, S. A. Seshia, T. S. Rosing, J. Venkatesh. **Distributed Control of a Swarm of Buildings Connected to a Smart Grid,** *1st ACM International Conference on Embedded Systems For Energy-Efficient Buildings (BuildSys), 2014*

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Energy Landscape of the USA in 2008

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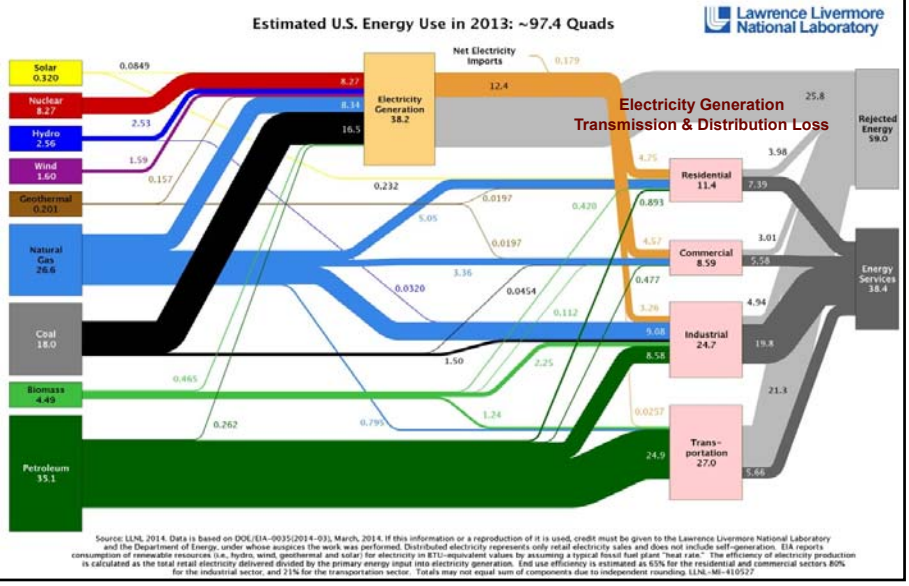

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Distributed Generation & Storage

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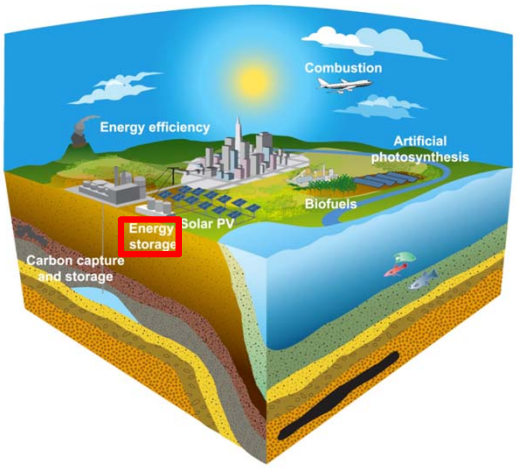
Energy For a Sustainable Future



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Courtesy of Lawrence Berkeley National Lab

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Distributed Generation & Storage

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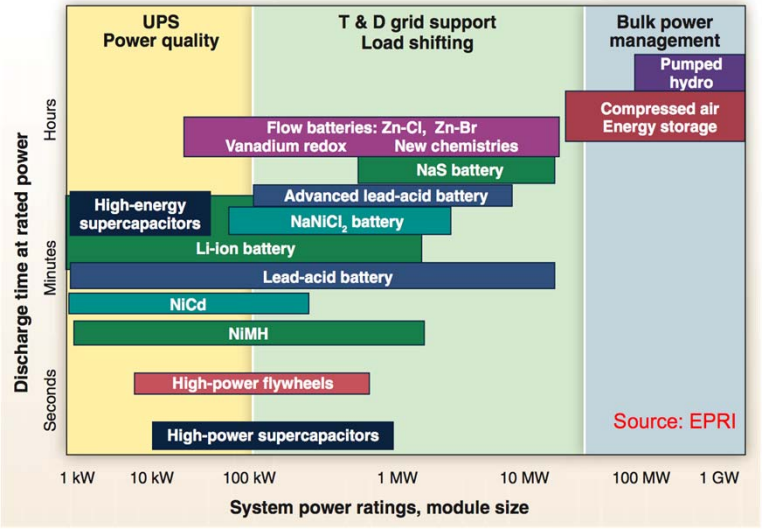

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Courtesy of Lawrence Berkeley National Lab

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A Living Laboratory for Sustainability

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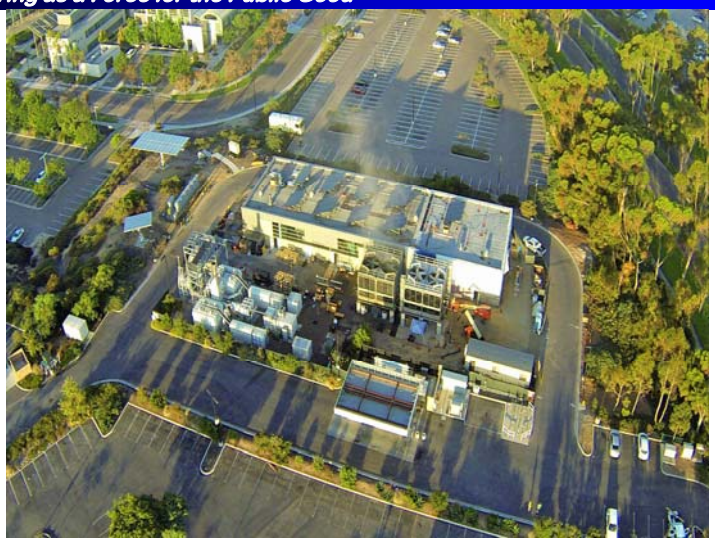

45MW Microgrid -- 6MW Solar Penetration
3MWh ESS

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Innovation Needed in Energy Storage

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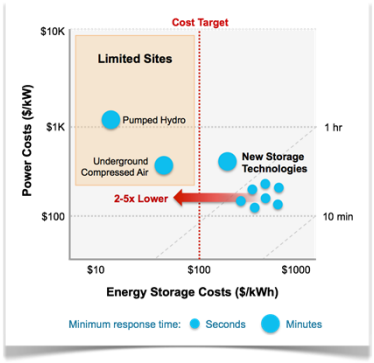
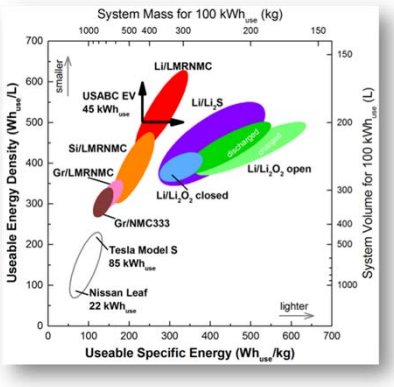


Dr. Ping Liu ARPA/e



Courtesy of Argonne National Lab

Goals to Reach in the Next Decade:
Increase Energy Density 2X
Lower the Cost Wh/Kg 2X

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Why We Need Better Batteries

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Low power
Safety


High power
($/kW)
High energy
(Wh/kg & /L)


System cost
($/kWh)
Reliability

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Imaging Atoms in a Working Battery!

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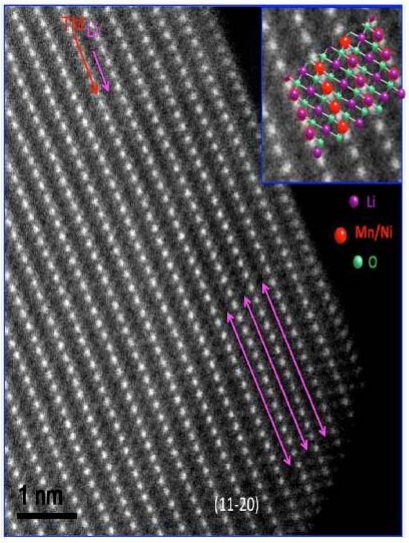

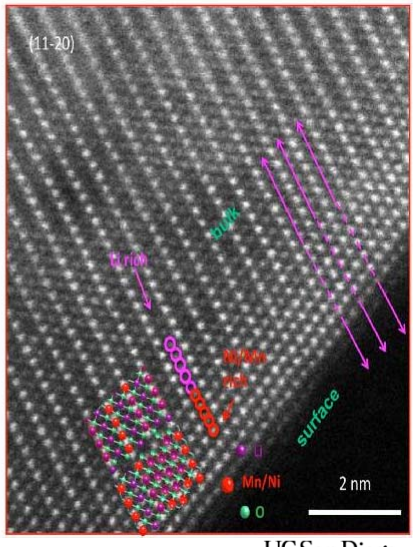

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Advanced Robotics and Controls

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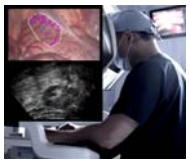
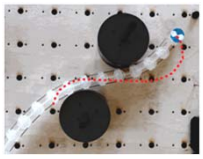


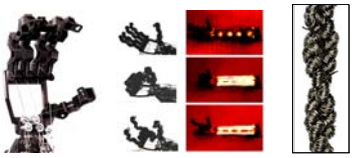
Medical Robotics

- Algorithms for robot-assisted control of instruments
- Augmented Reality to "see under the tissue"
- Design of smart, robotic instruments for new applications



Dexterous, Flexible Robotics

- Design and control of soft, flexible robots
- biomimetic locomotion and manipulation
- Flexible robotic applications in medicine, automotive/aerospace, military



Robotic Actuators and Biomimetic Design

- Novel actuators and biomimetic mechanisms
- Applications for robotic limbs, prostheses and orthoses
- Provide insight into how nature controls similar biology

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Michael Yip, Electrical and Computer Engineering

UC San Diego Jacobs School of Engineering

Smart Factories

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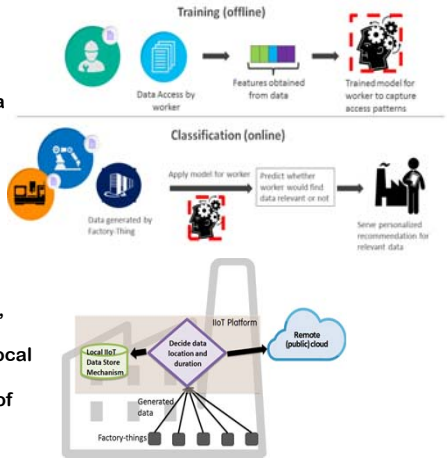
Recommendation System for Smart Factory
IIoT Data Access and Cloud Storage

- Information overload in smart factories
  - Workers access data for monitoring and reporting
  - Overwhelmed by size and diversity of data
- Data Access Recommendation System
  - Connect factory workers with relevant IIoT data
- Hierarchical Cloud Storage
  - Achieve trade-off between time to access, bandwidth used, and storage cost
  - Advanced analytics identify and store in local cloud frequently used and sensitive data
  - Sampling techniques determine duration of data storage based on predicted usage



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Center for Wireless COMMUNICATIONS

Sujit Dey, Truong Nguyen; in collaboration with KETI

UC San Diego Jacobs School of Engineering

Real-time Object Recognition

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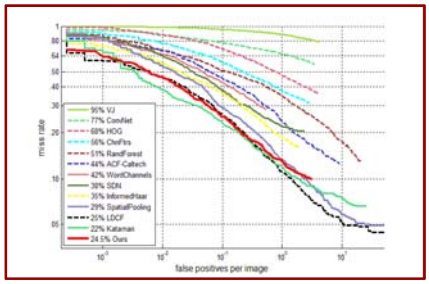
- Goal:
  - efficient classifiers that optimize trade-off between object detection accuracy and speed
  - real time classification of 1,000,000 image windows per second
- Methods:
  - cascades of deep learning classifiers learned with boosting
- Applications:
  - robotics, smart vehicles, state of the art pedestrian detection



SVCL UCSD **Nuno Vasconcelos,** Electrical and Computer Engineering UC San Diego Jacobs School of Engineering

Robotic Teams

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Human-swarm interaction and resource allocation in robotic teams

Goal: enable human to easily specify swarm behaviors for:

- Creating a safety perimeter
- Searching an urban environment
- Rerouting traffic
- Achieving area coverage
- Creating egress path for victims
- Providing situational awareness

Turtlebots

Parrot quadrotors

Android app

Jorge Cortez, Sonia Martinez, Multi-Agent Robotics Laboratory UC San Diego Jacobs School of Engineering

Tensegrity Duct-Climbing Robot

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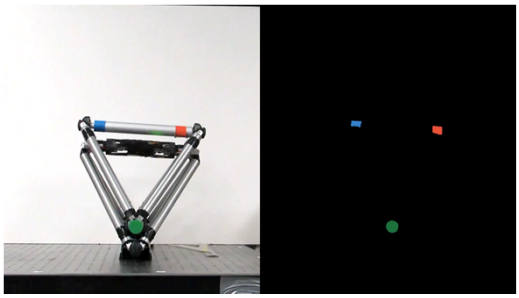
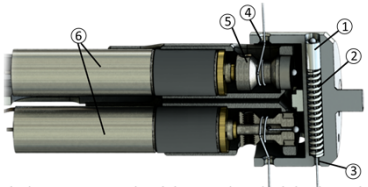
design by
Jeff Friesen





Two nested tetrahedra interconnected by actuatable tendons. Chimneys up ducts like a rock climber. Maneuverable, strong, and mass/volume efficient. Precision construction.

Thomas Bewley, Mechanical and Aerospace Engineering

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IceCube

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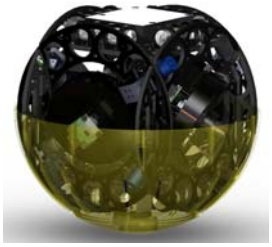
design by
Andrew
Cavender



IceCube (top, patent pending) accelerates by gimbling CMGs (heavy flywheels) which store rotational inertia. Zippy!

Competing GuardBot design (right) accelerates by moving a mass to the size of sphere, causing it to roll. Not so zippy.

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Sensor Balloons in Hurricanes

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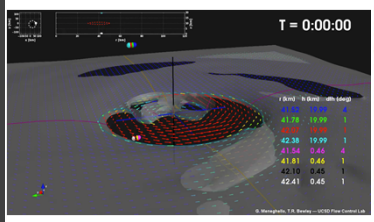
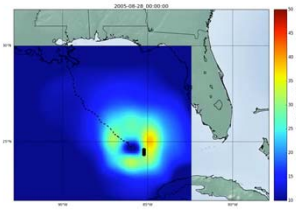
control design by Gianluca Meneghello

Underactuated control of sensor balloon distribution in hurricanes

Leverage predictable stratification of hurricane flowfield (inflow towards core at low altitudes, outflow at high altitudes) to regulate balloon distribution.

Persistent in situ measurements of temperature, pressure, humidity, winds, and precipitation over hurricanes. Better and cheaper than dropsondes!





Altitude cycling balloon technology developed by *Thin Red Line*.

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Multiagent Coordination

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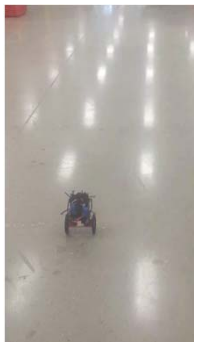
Multiagent coordination for building exploration

Challenge: alarm goes off at large superstore. First responder at scene needs situational awareness asap.

collaboration with Peter Yanofsky et al. *WowWee Robotics* and Clark Briggs et al. *ATA Engineering*

Solution: Send in the 'bots! Several quick/inexpensive toy-grade bots with IR cameras for thermal measurement, electronic noses for fume detection, and cellphone-grade electronics for mapping and communication.



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Thomas Bewley, Mechanical and Aerospace Engineering

UC San Diego Jacobs School of Engineering

Embedded Control & Robotics Course

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Senior/MS-level. "Capstone".
UCSD + extensive industry involvement.
Turning into a Massively-Open Online Course (MOOC) with hardware.

Inexpensive kits: EduMIP, EduRover
Four Stages:
*** *Build*, and extend the design.**
Collaborative mechanical & electrical CAD.
3D printing, custom PCB design/fab.
*** *Model* electrical and mechanical properties.**
Kinematics & Dynamics. Linear Circuits.
PWM, H-Bridges, encoders.
*** *Program* in embedded linux and C.**
Graphical programming. SPI, I2C, GPS, R/C.
Multithreading. RTOSs. Low-cost ARMs.
*** *Feedback Control Design.* Interconnection of continuous-time plant and low-pass filters with discrete-time microcontroller.**

Vehicle designs by James Strawson, commercialized in collaboration with Peter Yanofsky et al., *WowWee Robotics.*

Thomas Bewley, Mechanical and Aerospace Engineering
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Biologically Inspired Robotic Design

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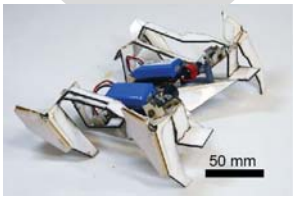
Autonomous Soft Systems

Self-Assembly by Folding

Functionally Graded Materials

Soft Robotics, 1:3, pp. 213-223



Science, 345:6197, pp. 644-646

Science, 349:6244, pp. 161-165

Bioinspired Robotics and Design Lab

Michael Tolley, Mechanical and Aerospace Engineering
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Please Join Us

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Meet world leaders developing ubiquitous consumer robotics for the benefit of society. Connect with San Diego's robotics community. Explore the technology showcase.

Confirmed Speakers


Andrea Chiba
Cognitive Sciences Prof.
UC San Diego


Todd Coleman
Bioengineering Prof.
UC San Diego


Rob High
VP & CTO, Watson Solutions
IBM Software Group


Todd Hylton
Executive Vice President
Brain Corporation


Paolo Pirjanian


Jonathan Sorger
Senior Director of Medical Research
Intuitive Surgical


Mohan Trivedi
Electrical Engineering Prof.
UC San Diego


Yulun Wang
Chairman & CEO
In Touch Health

Remarks


Matt Grob
CTO
Qualcomm Technologies, Inc.


Albert P. Pisano
Dean
Jacobs School of Engineering

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Invitation to UC San Diego

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Thank You!

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