

CUSTOM-MADE ORGANISMS "R" US
Synthetic biology is a brand-new industry
P. 09

MIND CONTROL—SCI-FI NO LONGER
Optogenetics and the new neuroscience
P. 26

THE ONCE AND FUTURE SEMICONDUCTOR
For transistors, a germanium solution
P. 40

WHY GESTURE WILL BEAT TOUCH
You'll light up a room by waving your hand
P. 46

IEEE
SPECTRUM

FOR THE TECHNOLOGY INSIDER | 12.16

A Light in the Dark

How a band of volunteers brought electricity and the Internet to an ancient monastery high in the Himalayas **P. 32**

A TECH EXPEDITION





32

LIGHTS FOR THE ENLIGHTENED

Engineers volunteer to electrify a remote monastery in the Himalayas with solar power.

BY JEAN KUMAGAI

26

A New Kind of Wireless Mouse

Neuroscientists can control a mouse's brain and behavior using optogenetic technology.

By Ada Poon

40

Switching Channels

Replacing silicon with germanium in transistor channels could lead to big gains.

By Peide D. Ye

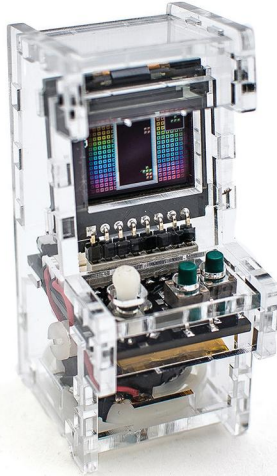
46

Wave Hello to the Next Interface

Good-bye, touch. The next user interface will be ultrasound.

By David Horsley

On the cover Photograph for *IEEE Spectrum* by Paula Bronstein



09

News

Synthetic Biology's Robot Revolution

A Boston factory shows the future of genetic engineering.

By Eliza Strickland

- 11 The Birth of Zcash
- 12 A Robot That Smokes
- 13 Why Southern China Broke Up Its Power Grid
- 16 The Big Picture: Dexterity in Robotic Hands

19

Resources

2016 Holiday Gift Guide

From the bench to the skies, a gift for every geek and budget.

By Stephen Cass

- 22 Hands On: Revisiting the History of Home Robot Kits
- 68 Past Forward: VR Goggles, Circa 1963

08

Opinion

Ending Energy Poverty, One Solar Grid at a Time

IEEE Smart Village aims to end energy poverty worldwide.

By Susan Hassler

- 04 Back Story
- 06 Contributors
- 24 Numbers Don't Lie: Will China Go the Way of Japan?
- 25 Technically Speaking: Cloud Computing's Metaphorical Lingo

Online

Spectrum.ieee.org

Build Your Own Air Theremin

IEEE Spectrum's Stephen Cass combines a range sensor, a vintage Casio keyboard, and an Arduino Mega to create a musical instrument you can play with your whole body. The result is quite possibly the most epic conference room dance party the world has ever seen. Watch it now: <http://spectrum.ieee.org/danceparty1216>

ADDITIONAL RESOURCES

Tech Insider / Webinars

Available at spectrum.ieee.org/webinar

- ▶ Sensor Fusion: Potential, Challenges, and Applications—6 December
- ▶ Innovation in Transformers: Alternative Fluids on the Rise—7 December
- ▶ Acoustics Simulation in Transducers, Mobile Devices, and Hearing Aids—15 December
- ▶ **MASTER BOND RESOURCE LIBRARY**
<http://spectrum.ieee.org/static/master-bond-resource-library>
- ▶ **NEW PRODUCT RELEASE LIBRARY**
<http://spectrum.ieee.org/static/new-product-release-library>
- ▶ **WHITE PAPERS**
<http://spectrum.ieee.org/whitepapers>

The Institute

Available at theinstitute.ieee.org

- ▶ **DIGITAL SENSES** Technology that lets people enhance reality or even escape it is quickly evolving. We can experience augmented reality with smartphones and smart glasses, immerse ourselves in different scenarios with virtual reality headsets, and restore or enhance sensory experiences with human-augmentation technologies. This special report spotlights these three areas, in which the IEEE Digital Senses Initiative is leading the way.
- ▶ **REALITY CHECK** Journalists and researchers are discovering ways in which VR can help people better understand the world around them, and even themselves.
- ▶ **AUGMENTED WORLD** Member Ori Inbar wants to see a billion people adopt AR technologies by 2020. This year he launched Super Ventures, a venture capital firm to help entrepreneurs innovate in this area.

IEEE SPECTRUM

(ISSN 0018-9235) is published monthly by The Institute of Electrical and Electronics Engineers, Inc. All rights reserved. © 2016 by The Institute of Electrical and Electronics Engineers, Inc., 3 Park Avenue, New York, NY 10016-5997, U.S.A. Volume No. 53, Issue No. 12, North American edition. The editorial content of IEEE Spectrum magazine does not represent official positions of the IEEE or its organizational units. Canadian Post International Publications Mail (Canadian Distribution) Sales Agreement No. 40013087. Return undeliverable Canadian addresses to: Circulation Department, IEEE Spectrum, Box 1051, Fort Erie, ON L2A 6C7. Cable address: TRIPLEEE. Fax: +1 212 419 7570. INTERNET: spectrum@ieee.org. ANNUAL SUBSCRIPTIONS: IEEE Members: \$21.40 included in dues. Libraries/institutions: \$399. POSTMASTER: Please send address changes to IEEE Spectrum, c/o Coding Department, IEEE Service Center, 445 Hoes Lane, Box 1331, Piscataway, NJ 08855. Periodicals postage paid at New York, NY, and additional mailing offices. Canadian GST #125634188. Printed at 120 Donnelley Dr., Glasgow, KY 42141-1060, U.S.A. IEEE Spectrum circulation is audited by BPA Worldwide. IEEE Spectrum is a member of the Association of Business Information & Media Companies, the Association of Magazine Media, and Association Media & Publishing. IEEE prohibits discrimination, harassment, and bullying. For more information, visit <http://www.ieee.org/web/aboutus/whats/policies/p9-26.html>.