How low can you go?

NEBNext® Single Cell/ Low Input Library Prep Kit

With this unique streamlined method, high-quality, full-length transcript sequencing libraries are made directly from single cells, or from as little as 2 pg – 200 ng of total RNA.

• Detect more transcripts, including low-abundance transcripts
• Obtain uniform, full-length transcript coverage, regardless of input amount or sample type
• Save time with a streamlined workflow, minimal handling steps and hands-on time

Visit NEBNext.com to request your sample today.

Superior transcript detection with the NEBNext Single Cell/Low Input RNA Library Prep Kit

Sequencing libraries were generated from Jurkat single cells (6 replicates) using the NEBNext Single Cell/ Low Input RNA Library Prep Kit, or the SMART-Seq® v4 Ultra™ Low Input RNA Kit for Sequencing plus the Nextera® XT DNA Library Prep Kit. Libraries were sequenced on an Illumina® NextSeq® 500. Each dot represents the number of transcripts identified at the given Transcripts Per Kilobase Million (TPM) range, and each box represents the median, first and third quartiles per replicate and method. Salmon 0.6 was used for read mapping and quantification of all GENCODE v25 transcripts. Increased identification of low abundance transcripts is observed with the NEBNext libraries.

One or more of these products are covered by patents, trademarks and/or copyrights owned or controlled by New England Biolabs, Inc. For more information, please email us at gbd@neb.com. The use of these products may require you to obtain additional third party intellectual property rights for certain applications. ILLUMINA®, NEXT-SEQ®, and NEXTERA® are registered trademarks of Illumina, Inc. SMART-SEQ® and ULTRA® are registered trademarks of Takara Bio, Inc. © Copyright 2018, New England Biolabs, Inc.; all rights reserved.
CALL FOR PAPERS

Spring Meeting registrations include MRS Membership July 1, 2019 – June 30, 2020

www.mrs.org/spring2019

Meeting Chairs
Yuping Bao  The University of Alabama
Bruce Dunn  University of California, Los Angeles
Subodh Mhaisalkar  Nanyang Technological University
Ruth Schwaiger  Karlsruhe Institute of Technology—Institute for Applied Materials
Subhash L. Shinde  University of Notre Dame

Don’t Miss These Future MRS Meetings!
2019 MRS Fall Meeting & Exhibit
December 1–6, 2019, Boston, Massachusetts

2020 MRS Spring Meeting & Exhibit
April 13–17, 2020, Phoenix, Arizona
Visit the Highlands of Guatemala during the festive season. Explore the historic cities of Chichicastenango and Antigua, and village life around the jewel of the Americas, Lake Atitlán, which is surrounded by spectacular volcanoes. Explore the finest Mayan ruins in Central America—Tikal, Quirigua and Copan with fantastic archaeological sites, spider monkeys, macaws and toucans! $3,995 per person + air.

For a detailed brochure, call (800) 252-4910
All prices are per person twin share + air.

BETCHART EXPEDITIONS Inc.
17050 Montebello Rd, Cupertino, CA 95014
Email: Info@betchartexpeditions.com
www.betchartexpeditions.com
Lundbeck Foundation calls for nominations for

THE BRAIN PRIZE 2019

Nominations must be received by 1 September 2018

The prize of €1 million is awarded to researchers for outstanding contributions to neuroscience – from basic to clinical.

The Brain Prize is open to researchers around the world.

Nominations will be reviewed by the Selection Committee:

Anders Björklund, Sweden, Chairman
Joseph Coyle, USA
Geoffrey Donnan, Australia
Catherine Dulac, USA
Story Landis, USA
Richard Morris, United Kingdom, Vice-Chairman
Mu-ming Poo, China
Philip Scheltens, The Netherlands
Irene Tracey, United Kingdom

Lundbeck Foundation encourages diversity in nominees.

For the nomination form and details of the nomination procedure, please visit www.thebrainprize.org.
Seeing is believing: R&D applications of computer vision

Once a technology that only existed in the realm of science fiction, artificial intelligence (AI) has moved out of research labs and into everyday products. Powering much of the progress in AI is computer vision, a technology concerned with building software that can gather and process visual information. Recognizing individuals in photos, reading X-rays, and making robotic systems on factory floors smarter are just a few of the applications of this promising new field.

Most people take vision for granted, not thinking twice about the massive amount of computation our brains carry out just to pick up a fork or catch a ball. It is only in recent years that computers have become quick enough, powerful enough, and small enough to enable practical applications for computer vision. The most cutting-edge computer vision uses deep learning, an area of AI inspired by the human brain. Deep learning algorithms use artificial neural networks (ANNs)—layers of connected nodes that analyze and pass information along to each other, in a way similar to the process by which neurons communicate.

Show a neural network a selfie, and one layer of neurons will recognize broad strokes like the outline of a face. Another will focus on the space between features on the face, like the distance from the eyes to the mouth. More still will look at the shape of an ear. From there, the algorithm can figure out if it’s a photo of a person or even who that person is.

“In most computer vision tasks, neural networks generate the best algorithms, hands down,” says Jiaya Jia, Distinguished Scientist in the YouTu Lab at Tencent, a global leader in Internet-related services and products, entertainment, and AI located in Shenzhen, China.

The engineers behind computer vision try to mimic what ANNs do within the human visual system. But machines have an advantage, in that they don’t have to rely on the limited light spectrum that people use, and can employ sensors to fill out how they see the world.

“Computer vision works better than human vision in many tasks, such as facial recognition and image classification; while in others requiring reasoning, there is still a long way to go,” says Jia. “It is easy for humans to know how objects relate to each other. We can make a story from just one picture—computers are still far from this level of understanding and imagination.”

As this technology is developed, new realms of discovery are possible. Computer vision and AI are still in their early days, and there is much more to come. Advances in computer vision could supercharge AI and give us all the things science fiction stories promise—self-driving cars, robotic butlers, and even long-distance space travel.

Learning by doing: How AI works

Computer vision, like most AI systems, needs a trove of data from which to learn. Researchers go through and carefully label this data with features they want the AI to interpret. For computer vision tasks, researchers collect hundreds—or more likely thousands—of images to be analyzed. That labeled data becomes the set of examples on which the AI is trained to categorize or find patterns. To test its learning efficacy, researchers challenge the AI to correctly categorize new, unlabeled images.

Besides the human labor that goes into collecting, annotating, and preparing massive datasets, a significant hurdle is the large amount of computing power required to run the training algorithm. Cheap, online services let researchers train their algorithms in the cloud instead of investing thousands of dollars on powerful computers. However, it can still take hours or days to get results.
Smile for the camera: Image and video recognition

One of the most important advancements in ANNs came from ImageNet, a database of more than 14 million labeled images collected and released in 2009. The ImageNet Challenge, a contest asking participants to create an algorithm that could categorize photos as well as humans, didn’t produce winners until 2012, when a team using a deep learning algorithm achieved significantly better results than any previous attempts.

Today, some of the most common ways people interact with computer vision—including automated tagging of images and face recognition in photographs—originated with the technology that bested ImageNet. These applications can be helpful with certain tasks, like doing visual searches when online shopping and automatically tagging social media photos.

In addition to image recognition, photo editing has also gotten a boost from this new technology. There are now algorithms for image segmentation, a component of computer vision that helps break down different parts of a picture; for example, by differentiating the background from people posing in the foreground. Users can edit photos rapidly, making them look like they’ve been professionally retouched.

Visual recognition capabilities are also being applied to video footage. Computer vision algorithms can assess a camera’s video feed and flag critical parts so that a human doesn’t have to comb through hours of footage. Understanding the emotions of individuals in footage is still a work in progress but has a few early adopters. Some Chinese schools—like Hangzhou Number 11 High School in the country’s eastern Zhejiang Province—are experimenting with cameras called “smart eyes” that track student engagement in class.

20/20 vision for robots

Going from a 2D world of images to 3D data presents a different set of challenges as well as a host of new opportunities. One area showing promise involves endowing robots with computer vision.

Robots began hitting manufacturing floors in the 1960s. These devices could lift heavy weights, do repetitive tasks, and carry out precise measuring for hours at a time, easily besting humans.

“It’s always been about building things that can do something humans couldn’t,” says Danica Kragic, a robotics professor at the KTH Royal Institute of Technology in Stockholm, Sweden.

With 40% of our brain dedicated to processing visual information, it’s important to understand to what extent visual information is needed if we are creating machines that mimic us and share our world, says Kragic. “We humans use visual feedback in just about everything we do,” she explains.

Machines able to process visual information could do more sophisticated work in factories and might even make their way into our homes. Some skills, like picking up squishy items that change shape with pressure, are still out of reach for robots. That’s because humans gain more than just visual information from sight; we also pick up cues about the physical property of an object and the physics needed to interact with it. Machines need to be able to gather that type of information to move effortlessly through the physical world as humans do.

“Among the five senses, vision is one of the most important, since it gives us the ability to comprehend a complicated world,” says Jia. “Likewise, computer vision commits to the task of letting computers see and directly interact with the environment as we do.”

Empowering robots with sensors that could better map out the world is the next iteration of the technology that could have them doing things they are unable to do today. cont.>>
Coming to a road near you: Self-driving cars

A holistic understanding of the world is also crucial for autonomous vehicles (AVs), one of the best-funded and most talked about areas in AI development. Besides cameras, most driverless cars use lidar, radar, GPS, and perception algorithms to navigate.

“A lot of the algorithms we use draw from computer vision, but now it’s more than camera data,” says Raquel Urtasun, an associate professor at the University of Toronto and head of Uber’s Advanced Technologies Group, also in Toronto, Canada. “We want to give our cars more than just our eyes.”

Companies like Uber hope to get AVs on the road and carrying passengers by 2020. These cars will only drive preselected routes or require people in the driver’s seat ready to take over in case any issues come up. The ultimate hope is for this technology to become truly autonomous so that riders can do other activities besides watching the road.

To get there, advances in both hardware and software are needed, Urtasun says. On the hardware side, lidar can cost tens of thousands of dollars, making it too expensive for wide-scale deployment. For AV software development, engineers need to find a way to make AI better able to “generalize,” or to differentiate between different objects. For example, if a human driver sees something unexpected in the road like a downed power line, they understand that they need to go around it. But if a self-driving car approaches something it hadn’t experienced in training, it might not react safely because it can’t tell it apart from other objects.

Urtasun says she is hopeful her work to improve sensors and training algorithms won’t be in vain, even if AVs are not quite ready for prime time. Fortunately, she says, “You can tackle many other problems with the technology.” Improved lidar could make mapping and land surveys more accurate, and even nonautonomous cars equipped with sensors could help reduce traffic.

Special delivery: Drones

Cars aren’t the only thing that researchers want to be able to move autonomously: Drones are also being trained to fly on their own. Some of the same kinds of problems that slow AV developers are faced by drone researchers. It’s difficult and expensive to get quality training data; different flying styles create new scenarios that drones need to be trained on; and regulations make it hard to test in some areas. Even after a drone is trained, flying it can still be very tricky.

“Anyone who has tried to steer a drone knows it’s not so easy,” says Tinne Tuytelaars, a professor at KU Leuven, a research university in Belgium. However, unlike errors with self-driving cars, mistakes with drones are less costly. “If a drone crashes,” Tuytelaars shrugs, “so be it.”

Drones are already being put to work in projects such as disaster relief and pipeline inspection. They could one day make deliveries and provide rides to passengers. Already, companies like Amazon and Boeing are testing drones that could eventually be able to drop packages off like mail carriers do today.

In some circumstances, multiple drones could occupy a single airspace and could better coordinate flight with each other than human pilots do. Making drones autonomous means they will be able to reduce costs, bringing the technology into the hands of more people and companies around the world.

Dr. Robot

After vehicular transportation, the medical field could see the most significant impact from computer vision. Already, AI algorithms can spot complications in medical images, such as bone fractures and pneumonia, more accurately than a radiologist can.

“The explosion of big data, specifically in the medical field, means we have so much to work with,” says Beatriz Remesego, an assistant professor at the Department of Computer Science at the University of Oviedo in Spain. “We’re using the data to solve more complicated problems than ever before.”

Last year, Google announced that it had developed image recognition algorithms to detect signs of diabetic retinopathy, an eye condition that causes blindness if left untreated. The algorithms worked as well as human experts at spotting small aneurysms in photographs of patient’s retinas, which indicate the early stages of the disease.

In 2017, Tencent also developed a system that can screen gastroscopy pictures for esophageal cancer, with a 90% accuracy rate in diagnosing preliminary cases of the disease. The software, called the AI Medical Innovation System (AIMIS), is already in use at more than 100 hospitals across China and could one day be applied to help diagnose diabetic retinopathy, lung nodules, cervical cancer, and breast cancer.
Other AI-powered tools from other companies, such as Infervision, in Beijing, China, are being used to spot strokes faster, giving patients a better chance of surviving. The U.S. Food and Drug Administration recently announced it was going to streamline its process to help AI products get approval more quickly.

Instead of replacing doctors, however, these tools from other companies are meant to work as advisers rather than practitioners. But computer vision could speed up this work and allow regions with fewer doctors to receive more care. These innovations are also being used to minimize invasive or dangerous procedures. For example, computerized tomography (CT) scans hold more information than X-rays but expose a patient to more radiation. Using an X-ray, AI can now approximate what a CT scan would show a doctor.

“Medical imaging is an area where computer vision could really have an impact, by providing additional information,” says Ramin Zabih, a professor of computer science at Cornell Tech and a research scientist at Google Research, in New York City, New York. “And the history of medicine has shown that when you can provide more data to practitioners, it can mean better outcomes for patients.”

**Near and far: Edge devices and spacecraft**

As impressive as all this work seems, the future could be even brighter for computer vision. One of the biggest changes that could soon impact the industry is the edge device, defined as any hardware that “controls data flow at the boundary between two networks.” Most AI processing needs to be done on big, remote cloud servers, because running these algorithms is so computationally intensive. Edge devices, on the other hand, are built with enough processing power to work locally. And with companies like Nvidia and Facebook building chips specifically to run AI, edge devices are becoming more commonplace. This allows for faster, more secure data processing, and opens the possibility of more custom training of AI with a user’s own data and increased customization of results for individuals.

“It’s going to drive a greater amount of innovation,” says Remi El-Ouazzane, former CEO of Movidius—a California-based company that designs specialized low-power processor chips for computer vision—and current chief operating officer of the AI products group at Intel, another California tech company that produces semiconductor chips and microprocessors.

El-Ouazzane says billions of devices could be infused with AI and work on the edge, from smart home devices and surveillance cameras to autonomous cars. This could create technology capable of finding missing people by scanning images of crowds, for instance, or able to alert a parent when their child hasn’t brushed their teeth before bed.

“It’s not an ‘if,’ it’s a ‘when,’” he says. Looking beyond the microworld of edge devices, astronomers—who work with massive datasets gathered from the expanses of space—are especially interested in computer vision. For example, a contest on Kaggle, an online platform for predictive modeling and analytics competitions, had researchers look at astronomical images to discover more about the dark matter that dominates our universe; they relied on deep learning and computer vision techniques.

Moreover, an entire research incubator is dedicated to using AI to further our understanding of space. Frontier Development Lab (FDL) is a public–private partnership between NASA and companies like Intel AI, Google Cloud, Lockheed, and IBM. FDL brings astronomers and computer scientists together for eight weeks in Silicon Valley, California, to tackle problems such as understanding solar flares, mapping the moon, and finding asteroids.

According to James Parr, one of the founders of FDL, the program couldn’t succeed without computer vision. In fact, NASA’s Jet Propulsion Laboratory, in Pasadena, California, was essential in the invention of the camera technology that powers most of the computer vision software currently in operation.

“There’s a symbiosis between computer vision and the space program,” Parr says. “It’s a story the space industry doesn’t talk about enough.”

Space exploration will be impacted similarly, with AI being essential for travel to Mars and beyond. The lag in communication between space travelers and earth command centers means systems will have to be capable of autonomous decision-making, with visual data driving many of those decisions.

“As we expand outwards, we will need robots and autonomous systems that will prepare and assist astronauts, help build structures, and locate and extract resources,” Parr says. “It’s an exciting time for discovery and exploration.”

This exhilarating time of discovery extends to finding out how computer vision will change life on earth. There will likely be new technological hurdles to overcome as AI expands into even more areas. But when we look back on the history of AI, giving computers the gift of sight may prove to be the most important advancement of all. Machines that can see will surely take us into a brighter future.

---

**Tencent YouTu Lab**
Exceptional scientists wanted

Present your work to the world

Are you a representative of the upcoming generation of thought leaders in your field? Together we look forward to your application for the new Sartorius & Science Prize for Regenerative Medicine & Cell Therapy.

Apply now!
www.passionforscience.com/prize
Cell-Free Protein Expression
myTXTL is a fast, easy-to-use solution for protein expression in vitro. Gene transcription (TX) and translation (TL) is executed in a single reaction tube by a highly efficient cell-free system that utilizes the endogenous TXTL machinery from *Escherichia coli*. This all-in-one solution offers convenient, one-step gene expression from a simple nucleotide template for various applications in synthetic biology and biomanufacturing. The system employs endogenous core RNA polymerase and primary sigma factor 70 (σ70) present in the *E. coli* cytoplasm. The technology has been well characterized and proven useful for applications including high-yield protein synthesis, prototyping of biomolecular networks, bacteriophage production, and high-throughput protein expression analysis. myTXTL kits contain ready-to-use Master Mix comprised of *E. coli* cell extract, energy buffer, and amino acids mix optimized for coupled TXTL.

**Arbor Biosciences**
For info: 734-998-0751
www.arborbiossci.com

N-Glycan Assay
The N-Glycan Assay allows for in-depth profiling of immunoglobulin G glycosylation. This physicochemical assay, developed by Sartorius Stedim Biotech's subsidiary, BioOutsource, and offered in combination with its unique Antibody Dependent Cell Cytotoxicity (ADCC) assay platform, combines data on molecular structure with a key therapeutic mechanism of action. This combination will generate comprehensive, highly accurate biosimilar comparability data, driving shorter drug-development timelines. BioOutsource's new assay enzymatically removes glycans from the antibody, functionally derivatizes them, and separates the glycans by UHPLC. The glycans are then identified by online electrospray ionization mass spectrometry, enabling confident assignment and precise quantification of their different structures. The N-Glycan Assay is one of a range of orthogonal methods, including analysis by CD16a (FcγRIIA) and surface plasmon resonance binding, as well as ADCC functional assays that BioOutsource offers to provide a detailed testing package for generating evidence suitable for regulatory submissions.

**Sartorius Stedim BioOutsource**
For info: +44-(0)-141-946-4222
www.biooutsource.com

Kinase Inhibition Assay
BÜHLMANN's Kinase Inhibition Assay offers a quick, precise method to evaluate inhibitors of immune-cell signaling pathways, using inhibition of basophil degranulation as a surrogate readout cell-based system by means of flow cytometry. PI3K, BTK, and SYK signaling pathways involved in basophil activation have been implicated in allergic responses, autoimmune disorders, and cancer. Inhibitors of these pathways are a large focus for pharmaceutical companies, with several small-molecule inhibitors currently at different stages of development. Alterations in the expression of cell-surface basophil activation markers such as CD63 can be measured by flow cytometry. These surrogate markers allow for high-throughput assessment of compound efficacy, resulting in faster failure of ineffective compounds.

**BÜHLMANN Diagnostics**
For info: 844-300-9799
kinaseinhibitionassays.com

**Customized Resins**
Production of agarose resins requires precise control of many parameters, and the product range is based on the most common research and production requirements. However, we recognize that there are many specialized applications that are not currently served, and many separations that could be improved by a more appropriate bead, so we now offer customized resins to extend the range. Parameters that can be specified include size of beads, degree of crosslinking, concentration of agarose, type of activation, spacer arm length, and density of active groups. Agarose Bead Technologies Customized Resins are now available to cover all different types of orders, enabling you to choose specifications for your resin at an affordable price. In order to produce exactly what you require, we will work closely with you and share technical details as appropriate.

**Agarose Bead Technologies**
For info: 305-262-0177
www.abtbeads.com

**ELISA Kits**
Bioaim Scientific is an ELISA company dedicated to developing high-quality immunoassay kits and antibodies for both industrial and academic scientific research. We have more than 800 ELISA kits, covering human, mouse, rat, bovine, canine, equine, and porcine species. All kits are quality guaranteed and risk-free. We offer sandwich-based EasyTest ELISA kits (which require only one wash, decreasing variations and significantly saving time, as compared to standard ELISA), sandwich-based normal ELISA kits, and competitive ELISA (enzyme immunoassay) kits. In addition to providing testing services for all assay kits, Bioaim also offers a full complement of biomarker discovery services, diagnostics kit development, and assay development services.

**Bioaim Scientific**
For info: 416-286-6868
bioaimscientific.com

Electronically submit your new product description or product literature information! Go to www.sciencemag.org/about/new-products-section for more information.

Newly offered instrumentation, apparatus, and laboratory materials of interest to researchers in all disciplines in academic, industrial, and governmental organizations are featured in this space. Emphasis is given to purpose, chief characteristics, and availability of products and materials. Endorsement by *Science* or AAAS of any products or materials mentioned is not implied. Additional information may be obtained from the manufacturer or supplier.
Step up your job search with Science Careers

- Access thousands of job postings
- Sign up for job alerts
- Explore career development tools and resources

Search jobs on ScienceCareers.org today
Transforming the Future of Robotics

As a multidisciplinary online-only journal, Science Robotics publishes original, peer-reviewed, research articles that advance the field of robotics. The journal provides a central forum for communication of new ideas, general principles, and original developments in research and applications of robotics for all environments.

Learn more at: ScienceRobotics.org