A Crystal Ball for the Decade Ahead

From robots in the home to advance medicine via an app, Duke faculty offer ideas for the world of 2030

By Duke Today Staff

With a new decade dawning, we asked several Duke professors to hypothetically gaze into their crystal balls to tell us what they see happening in the years ahead.

Blockchain Is The Future

By Campbell Harvey

Blockchain, a unique database technology nearly impossible to hack, will fundamentally change the way we interact in the next 10 years.

Legacy items like paper passports, drivers' licenses, Social Security cards, could be replaced with blockchain technology. After verifying your identity through a facial scan or fingerprints, a blockchain database can be checked to determine whether you have a valid passport.
At the grocery store, scanning a QR code on a head of lettuce will instantly reveal where the lettuce was grown, whether it is organic, when it was picked, every stop on the supply chain, and how long it has been on the shelf.

Because blockchain is distributed with many identical copies, it eliminates a single point of failure. Second, you can only add to the database -- there is no editing of history. This provides a secure record of ownership for anything. Third, the database is cryptographically secure, making it extremely difficult to hack.

New payments systems using blockchain technology allow for near-instant payments with unprecedented security. In the next 10 years, we will see the end of monthly billing. If you watch 10 minutes of a movie, you pay for the 10 minutes in real time.

Blockchain technology enables many peer-to-peer applications including lending and borrowing, which will disrupt the current banking system. Currently, there are 2.2 billion people worldwide without access to banks. In 10 years, everyone will have bank access -- through their mobile device that is blockchain-enabled. And billions will have new access to internet commerce to both buy and sell goods and services.

*Campbell Harvey is a finance professor at The Fuqua School of Business.*

**Will My Home Robot Do More Than Vacuum?**

By Daniel Sorin

We already know the future of robotics because we've seen it in books, on TV and in movies for decades. Depending on your age, we imagine either C-3PO from "Star Wars," Rosie from "The Jetsons," "Wall-E" or any of Asimov's robots. These robots are highly capable of interacting with their environments and they have personality.
Today, most people assume that real-world robots have most of those capabilities, perhaps without the personality. Certainly a robot can autonomously walk over to a shelf, reach out and grab a requested book, and bring it to someone across the room. But even a 3-year-old child can do that! Yet the apex of home robotics is ... a Roomba?


Although it is easy to imagine a dexterous, clever robot, it is extraordinarily difficult to make one. Historically, there have been three technical challenges that have kept robots from becoming ubiquitous. A robot needs vision to perceive its environment and identify the objects within it. It needs intelligence to determine what tasks it should do and how to accomplish them. And it needs the ability to move throughout its environment and perform the desired tasks.

Fortunately, major advances in all three of those areas are going to enable the future to finally arrive soon, even if much later than expected. Vision technology has made remarkable strides, with increasingly inexpensive cameras now able to provide high-quality spatial perception. Intelligence continues to improve rapidly, driven by advances in machine learning
and artificial intelligence. And technology that began at Duke can now enable robots to dexterously manipulate objects without colliding with other objects or people.

Within the next 10 years, your home robot will do more than vacuum. It may even do what you thought robots could already do now.

*Daniel Sorin is a professor of electrical and computer engineering and of computer science.*

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**Health Care -- Circa 2030**

By Geoffrey Ginsburg

Following his heart attack, Jeff had his genome sequenced as part of a new employee health benefit. His wife and children were also sequenced as part of their participation in the All of Us Research Program (joinallofus.org).

The genome sequencing of Jeff’s wife revealed a number of gene variants that protected her from cancer. But Jeff’s history of heart disease and his genome data showed he had genetic variants for familial high cholesterol, which affects 1 in 250 people in our population and is what caused his heart attack.

Two of his children carry the same genetic variant, which is why his son Jack sent a stem cell sample to a company to develop a personalized physiologic model -- “Jack-on-a-chip” – which was used to select the drug most likely to reduce Jack’s cholesterol with the fewest side effects.

Jeff’s daughter, Jül, elected to undergo a new gene-editing procedure in which the genetic defect in the LDL receptor (responsible for removing cholesterol from the blood) is corrected and obviates the need for lifelong drug therapy.

Jeff has taken control of his risk for heart disease with genetically selected medications and a virtual health coach who helps him adhere to his lifestyle prescriptions. Smart phone and smart home devices help him and the coach monitor his physical activity, food and calorie/fat intake, sleep duration and stress.

One day Jeff awakens with a fever and sore throat and, after a conversation with a chat bot, is directed to swab his nose, place the swab on a biosensor attached to his phone and use the “I have a fever” app. The app indicates he is developing the flu, so does not need antibiotics and recommends he stay home from work to not infect coworkers. His GPS and sensor data are uploaded to the cloud where data analytics are used to model the potential for an emerging viral epidemic in his community. His data also alerts Amazon to drone-deliver Tamiflu and chicken soup to take care of his flu symptoms. A modern-day house call, you might say.
Dr. Geoffrey Ginsberg is director of the Duke Center for Applied Genomics and Precision Medicine.

**Speaking Of Medicine, “You-on-a-chip”**

By Shyni Varghese

Imagine a day when you can walk into a hospital and the health provider can prescribe the optimal drug based on a simple finger prick or a Q-Swab.

This should be possible in the not-too-distant future, thanks to Artificial Intelligence.

Say, for instance, you are a cancer patient. The oncologist draws blood from you that, along with the excised tumor, is sent to a research facility where the cells are converted to stem cells. Using the patient-derived stem cells, the facility can develop a patient-specific “you-on-a-chip” to identify the optimal drug with minimal side effects.

An early issue of Popular Mechanics Magazine featuring a rotating building.
Going beyond, your doctor can now use the screening results to precisely advise you on potential side effects and suggest preventive measures. These emerging technologies make the conventional approach of “one size fits all” a thing of the past.

“You-on-chip” can also be used to predict -- and therefore prevent -- episodes of environment-driven diseases such as pneumonia and allergies, and help healthcare providers anticipate therapeutic outcomes based on an individual’s lifestyle, including diet, exercise or environmental exposure. This will revolutionize medicine by allowing us to personalize health care the same way we personalize our diets, wardrobes or Alexa.

On a related topic, aging is a key factor that leads to compromised organ function and impaired healing. For example, kids’ broken bone often heal without complications. However, the same injuries for an aging person not only don’t heal, but often introduce other complications.

But it may be possible in the next decade to go to the nearby pharmacy and buy an implantable medical device (e.g., functional biomaterials) that can deliver molecules at the injury site that assist with tissue healing or reverse the aging and associated complications.

*Shyni Varghese is a professor in the Pratt School of Engineering and Duke Medical Center.*

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**Smarter Machines That Think At The Speed Of Light**

By David R. Smith

Despite dazzling progress made by the semiconductor industry, the typical computer still has serious shortcomings when trying to emulate tasks that human brains can achieve naturally.

The calculations and analysis we do when driving a car highlights the vast gap between conventional computing and what we might call neural computing. Our brains are capable of instantly identifying every detail in sight -- a lane marker, pedestrian, street sign, other car, pothole or other obstacle -- all of which informs our driving decisions within a few thousandths of a second. By contrast, it remains a major challenge for a computer to achieve the same performance.

To make computers more like our brains, different types of processors have been developed that simultaneously process vast quantities of data, as needed in applications from speech recognition to search engines.

But there is a cost. The electric charges and currents that carry and move data also dissipate energy. This energy cost adds up quickly (think billions of operations performed in a fraction of a second), leading to energy consumption that is unsustainable.
That's why we must continue to look beyond electronics to other technologies capable of performing computations with much less energy. Photonic computing -- in which light rather than electrons carries information -- is an emerging and promising technology that could allow us to escape current limitations. The energy needed to manipulate photons is orders of magnitude less than electrons, enabling exactly the kind of low-cost, scalable processors needed.

Neural computing chips requiring minimal amounts of energy will usher in the future much faster, allowing for intelligent robots to navigate through the world and make complex decisions; self-driving vehicles; personal assistants that detect medical conditions at the earliest stages; wearable devices that understand speech and can translate languages instantly, and who knows what else.

David R. Smith is director of the Duke Center for Metamaterials and Integrated Plasmonics.

**Storing Up On Energy**

By Brian Murray

By 2030, improved energy storage will transform how we get electricity, how reliable it is, even what we drive. It will also help America’s carbon emissions take a much-needed nosedive.

That's because storage is critical for making sure that renewable energy can serve up electricity even when the sun isn't shining or the wind isn't blowing -- for encouraging consumers to drive electric vehicles, and for businesses and communities looking to maintain reliability in the face of increasingly frequent climate disruption (hurricanes, wildfires, etc.)
An early issue of Popular Mechanics Magazine featuring a futuristic blast machine.
A lone breakthrough in storage technology won’t change the energy game -- one size won’t fit all. Instead, a portfolio of improved storage solutions will respond to a range of needs.

Over the next decade, reductions in the weight and cost of lithium-ion batteries will lead more Americans to install rooftop solar systems and drive electric vehicles with longer run times and improved performance.

Several technologies look promising to store power on a larger scale over much longer time periods. Vanadium-flow batteries can store much more energy than lithium-ion ones. Thermal storage traps heat or cool air in large volumes when generated by renewables and releases it for cooling or energy production when renewables are not available. And renewable energy can use electrolysis to produce pure hydrogen from water and store it as compressed gas or liquid for energy production later.

While these technologies aren’t yet ready for prime time, they are being pilot-tested now here (the U.S. Department of Energy is upping its investment in advanced storage) and abroad.

All of this will create a more reliable and clean energy system -- a key component of both adapting to and fighting climate change.

Brian Murray is director of the Duke University Energy Initiative

MOOCs Are So Yesterday

By Shawn Miller

Last decade brought us MOOCs, Massive Open Online Courses for a virtual classroom experience. Building on that, we hope to design learning experiences that can be online, global, flexible, hybrid and/or lifelong -- sometimes all at once.

For example, consider a hypothetical Duke alumna living in Singapore and working in the health care industry. She’s been reading some of the research on the coming impacts of machine learning on her industry, but wants to dive deeper to “level up” her knowledge and skills in this area. She finds out Duke is offering a series of online modules focused on health and machine learning that she can freely access anytime, anywhere.

She also learns that Duke is offering a way to connect to other alums who want to form small online learning communities around specific topics, and joins a weekly live online session where they discuss the most challenging aspects of the online modules.

Meanwhile, those same modules are being used by Duke medical students in Durham who want to improve their skills before attending fast-paced, in-person programs with faculty experts. The faculty experts soon learn about the alum group
and join in on one of the alums' weekly Zoom sessions.

This is just one example of how the audiences for learning are shifting. In addition to our undergrads and grad students, we now consider prospective students, alums, professional learners, local and regional learners, and our broader global networks when we design digital learning experiences.

Shawn Miller is director of the Duke Learning Innovation

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