Visualizing Scientific Big Data

Humans are visual creatures: our brain processes images 60,000 times faster than text, and 90 percent of information sent to the brain is visual. Visualization is becoming increasingly useful in the era of big data, in which we are generating so much data at such high rates that we cannot keep up with making sense of it all. In particular, visual analytics—a research discipline that combines automated data analysis with interactive visualizations—has emerged as a promising approach to dealing with this information overload. [18]

Neural networks are commonly used today to analyze complex data – for instance to find clues to illnesses in genetic information. Ultimately, though, no one knows how these networks actually work exactly. [17]

Hey Siri, how's my hair?" Your smartphone may soon be able to give you an honest answer, thanks to a new machine learning algorithm designed by U of T Engineering researchers Parham Aarabi and Wenzhi Guo. [16]

Researchers at Lancaster University's Data Science Institute have developed a software system that can for the first time rapidly self-assemble into the most efficient form without needing humans to tell it what to do. [15]

Physicists have shown that quantum effects have the potential to significantly improve a variety of interactive learning tasks in machine learning. [14]

A Chinese team of physicists have trained a quantum computer to recognise handwritten characters, the first demonstration of "quantum artificial intelligence". Physicists have long claimed that quantum computers have the potential to dramatically outperform the most powerful conventional processors. The secret sauce at work here is the strange quantum phenomenon of superposition, where a quantum object can exist in two states at the same time. [13]

One of biology's biggest mysteries - how a sliced up flatworm can regenerate into new organisms - has been solved independently by a computer. The discovery marks the first time that a computer has come up with a new scientific theory without direct human help. [12]

A team of researchers working at the University of California (and one from Stony Brook University) has for the first time created a neural-network chip that was built using just memristors. In their paper published in the journal Nature, the team describes how they built their chip and what capabilities it has. [11]

A team of researchers used a promising new material to build more functional memristors, bringing us closer to brain-like computing. Both academic and industrial laboratories are working to develop computers that operate more like the human brain. Instead of operating like a conventional, digital system, these new devices could potentially function more like a network of neurons. [10]

Cambridge Quantum Computing Limited (CQCL) has built a new Fastest Operating System aimed at running the futuristic superfast quantum computers. [9]

IBM scientists today unveiled two critical advances towards the realization of a practical quantum computer. For the first time, they showed the ability to detect and measure both kinds of quantum errors simultaneously, as well as demonstrated a new, square quantum bit circuit design that is the only physical architecture that could successfully scale to larger dimensions. [8]

Physicists at the Universities of Bonn and Cambridge have succeeded in linking two completely different quantum systems to one another. In doing so, they have taken an important step forward on the way to a quantum computer. To accomplish their feat the researchers used a method that seems to function as well in the quantum world as it does for us people: teamwork. The results have now been published in the "Physical Review Letters". [7]

While physicists are continually looking for ways to unify the theory of relativity, which describes large-scale phenomena, with quantum theory, which describes small-scale phenomena, computer scientists are searching for technologies to build the quantum computer.

The accelerating electrons explain not only the Maxwell Equations and the Special Relativity, but the Heisenberg Uncertainty Relation, the Wave-Particle Duality and the electron's spin also, building the Bridge between the Classical and Quantum Theories.

The Planck Distribution Law of the electromagnetic oscillators explains the electron/proton mass rate and the Weak and Strong Interactions by the diffraction patterns. The Weak Interaction changes the diffraction patterns by moving the electric charge from one side to the other side of the diffraction pattern, which violates the CP and Time reversal symmetry.

The diffraction patterns and the locality of the self-maintaining electromagnetic potential explains also the Quantum Entanglement, giving it as a natural part of the Relativistic Quantum Theory and making possible to build the Quantum Computer.

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Author: George Rajna

Preface

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Both academic and industrial laboratories are working to develop computers that operate more like the human brain. Instead of operating like a conventional, digital system, these new devices could potentially function more like a network of neurons. [10]

So far, we just have heard about Quantum computing that could make even complex calculations trivial, but there are no practical Quantum computers exist. However, the dream of Quantum computers could become a reality in coming future. [9]

Using a square lattice, IBM is able to detect both types of quantum errors for the first time. This is the best configuration to add more qubits to scale to larger systems. [8]

Australian engineers detect in real-time the quantum spin properties of a pair of atoms inside a silicon chip, and disclose new method to perform quantum logic operations between two atoms. [5]

Quantum entanglement is a physical phenomenon that occurs when pairs or groups of particles are generated or interact in ways such that the quantum state of each particle cannot be described independently – instead, a quantum state may be given for the system as a whole. [4]

I think that we have a simple bridge between the classical and quantum mechanics by understanding the Heisenberg Uncertainty Relations. It makes clear that the particles are not point like but have a dx and dp uncertainty.

Visualizing scientific big data in informative and interactive ways

Humans are visual creatures: our brain processes images 60,000 times faster than text, and 90 percent of information sent to the brain is visual. Visualization is becoming increasingly useful in the era of big data, in which we are generating so much data at such high rates that we cannot keep up with making sense of it all. In particular, visual analytics—a research discipline that combines automated data analysis with interactive visualizations—has emerged as a promising approach to dealing with this information overload.

"Visual analytics provides a bridge between advanced computational capabilities and human knowledge and judgment," said Wei Xu, a computer scientist in the Computational Science Initiative (CSI) at the U.S. Department of Energy's (DOE) Brookhaven National Laboratory and a research assistant professor in the Department of Computer Science at Stony Brook University. "The interactive visual representations and interfaces enable users to efficiently explore and gain insights from massive datasets."

At Brookhaven, Xu has been leading the development of several visual analytics tools to facilitate the scientific decision-making and discovery process. She works closely with Brookhaven scientists, particularly those at the National Synchrotron Light Source II (NSLS-II) and the Center for Functional Nanomaterials (CFN)—both DOE Office of Science User Facilities. By talking to researchers early on, Xu learns about their data analysis challenges and requirements. She continues the conversation throughout the development process, demoing initial prototypes and making refinements based on their feedback. She also does her own research and proposes innovative visual analytics methods to the scientists.

Recently, Xu has been collaborating with the Visual Analytics and Imaging (VAI) Lab at Stony Brook University—her alma mater, where she completed doctoral work in computed tomography with graphics processing unit (GPU)-accelerated computing.

Though Xu continued work in these and related fields when she first joined Brookhaven Lab in 2013, she switched her focus to visualization by the end of 2015.

Visualizing scientific big data in informative and interactive ways

The color-mapping tool was used to visualize a multivariable fluorescence dataset from the Hard X-ray Nanoprobe (HXN) beamline at Brookhaven's National Synchrotron Light Source II. The color map (a) shows how the different variables—the …more

"I realized how important visualization is to the big data era," Xu said. "The visualization domain, especially information visualization, is flourishing, and I knew there would be lots of research directions to pursue because we are dealing with an unsolved problem: how can we most efficiently and effectively understand the data? That is a quite interesting problem not only in the scientific world but also in general."

It was at this time that Xu was awarded a grant for a visualization project proposal she submitted to DOE's Laboratory Directed Research and Development program, which funds innovative and creative research in areas of importance to the nation's energy security. At the same time, Klaus Mueller—Xu's PhD advisor at Stony Brook and director of the VAI Lab—was seeking to extend his research to a broader domain. Xu thought it would be a great opportunity to collaborate: she would present the visualization problem that originated from scientific experiments and potential approaches to solve it, and, in turn, doctoral students in Mueller's lab would work with her and their professor to come up with cutting-edge solutions.

This Brookhaven-Stony Brook collaboration first led to the development of an automated method for mapping data involving multiple variables to color. Variables with a similar distribution of data points have similar colors. Users can manipulate the color maps, for example, enhancing the contrast to view the data in more detail. According to Xu, these maps would be helpful for any image dataset involving multiple variables.

"Different imaging modalities—such as fluorescence, differential phase contrasts, x-ray scattering, and tomography—would benefit from this technique, especially when integrating the results of these modalities," she said. "Even subtle differences that are hard to identify in separate image displays, such as differences in elemental ratios, can be picked up with our tool—a capability essential for new scientific discovery." Currently, Xu is trying to install the color mapping at NSLS-II beamlines, and advanced features will be added gradually.

In conjunction with CFN scientists, the team is also developing a multilevel display for exploring large image sets. When scientists scan a sample, they generate one scattering image at each point within the sample, known as the raw image level. They can zoom in on this image to check the individual pixel values (the pixel level). For each raw image, scientific analysis tools are used to generate a series of attributes that represent the analyzed properties of the sample (the attribute level), with a scatterplot showing a pseudo-color map of any user-chosen attribute from the series—for example, the sample's temperature or density. In the past, scientists had to hop between multiple plots to view these different levels. The interactive display under development will enable scientists to see all of these levels in a single view, making it easier to identify how the raw data are related and to analyze data across the entire scanned sample. Users will be able to zoom in and out on different levels of interest, similar to how Google Maps works.

The ability to visually reconstruct a complete joint dataset from several partial marginal datasets is at the core of another visual analytics tool that Xu's Stony Brook collaborators developed. This web-based tool enables users to reconstruct all possible solutions to a given problem and locate the subset of preferred solutions through interactive filtering.

"Scientists commonly describe a single object with datasets from different sources—each covering only a portion of the complete properties of that object—for example, the same sample scanned in different beamlines," explained Xu. "With this tool, scientists can recover a property with missing fields by refining its potential ranges and interactively acquiring feedback about whether the result makes sense."

Their research led to a paper that was published in the Institute of Electrical and Electronics Engineers (IEEE) journal Transactions on Visualization and Computer Graphics and awarded the

Visual Analytics Science and Technology (VAST) Best Paper Honorable Mention at the 2016 IEEE VIS conference.

At this same conference, another group of VAI Lab students whom Xu worked with were awarded the Scientific Visualization (SciVis) Best Poster Honorable Mention for their poster, "Extending Scatterplots to Scalar Fields." Their plotting technique helps users link correlations between attributes and data points in a single view, with contour lines that show how the numerical values of the attributes change. For their case study, the students demonstrated how the technique could help college applications select the right university by plotting the desired attributes (e.g., low tuition, high safety, small campus size) with different universities (e.g., University of Virginia, Stanford University, MIT). The closer a particular college is to some attribute, the higher that attribute value.

According to Xu, this kind of technique also could be applied to visualize artificial neural networks—the deep learning (a type of machine learning) frameworks that are used to address problems such as image classification and speech recognition.

"Because neural network models have a complex structure, it is hard to understand how their intrinsic learning process works and how they arrive at intermediate results, and thus quite challenging to debug them," explained Xu. "Neural networks are still largely regarded as black boxes. Visualization tools like this one could help researchers get a better idea of their model's performance."

Besides her Stony Brook collaborations, Xu is currently involved in the Co-Design Center for Online Data Analysis and Reduction at the Exascale (CODAR), which Brookhaven is partnering on with other national laboratories and universities through DOE's Exascale Computing Project. Her role is to visualize data evaluating the performance of computing clusters, applications, and workflows that the CODAR team is developing to analyze and reduce data online before the data are written to disk for possible further offline analysis. Exascale computer systems are projected to provide unprecedented increases in computational speed but the input/output (I/O) rates of transferring the computed results to storage disks are not expected to keep pace, so it will be infeasible for scientists to save all of their scientific results for offline analysis. Xu's visualization will help the team "diagnose" any performance issues with the computation processes, including individual application execution, computation job management in the clusters, I/O performance in the runtime system, and data reduction and reconstruction efficiency.

Xu is also part of a CSI effort to build a virtual reality (VR) lab for an interactive data visualization experience. "It would be a more natural way to observe and interact with data. VR techniques replicate a realistic and immersive 3-D environment," she said.

For Xu, her passion for visualization most likely stemmed from an early interest in drawing.

"As a child, I liked to draw," she said. "In growing up, I took my drawings from paper to the computer." [18]

Analysis software uses algorithms to visualize complex learning processes

Neural networks are commonly used today to analyze complex data – for instance to find clues to illnesses in genetic information. Ultimately, though, no one knows how these networks actually work exactly. That is why Fraunhofer researchers developed software that enables them to look into these black boxes and analyze how they function. The researchers will present their software at CeBIT in Hannover from March 20 to 24, 2017 (Hall 6, Booth B 36).

Sorting photos on the computer used to be a tedious job. Today, you simply click on face recognition and instantly get a selection of photos of your daughter or son. Computers have gotten very good at analyzing large volumes of data and searching for certain structures, such as faces in images. This is made possible by neural networks, which have developed into an established and sophisticated IT analysis method.

The problem is that it isn't just researchers who currently don't know exactly how neural networks function step by step, or why they reach one result or another. Neural networks are, in a sense, black boxes – computer programs that people feed values into and that reliably return results. If you want to teach a neural network, for instance, to recognize cats, then you instruct the system by feeding it thousands of cat pictures. Just like a small child that slowly learns to distinguish cats from dogs, the neural network, too, learns automatically. "In many cases, though, researchers are less interested in the result and far more interested in what the neural network actually does – how it reaches decisions," says Dr. Wojciech Samek, head of the Machine Learning Group at Fraunhofer Heinrich Hertz Institute HHI in Berlin. So Samek and his team, in collaboration with colleagues from TU Berlin, developed a method that makes it possible to watch a neural network think.

Machine learning enables customized cancer treatments

This is important, for instance, in detecting diseases. We already have the capability today to feed patients' genetic data into computers – or neural networks – which then analyze the probability of a patient having a certain genetic disorder. "But it would be much more interesting to know precisely which characteristics the program bases its decisions on," says Samek. It could be certain genetic defects the patient has – and these, in turn, could be a possible target for a cancer treatment that is tailored to individual patients.

Neural networks in reverse

The researchers' method allows them to watch the work of the neural networks in reverse: they work through the program backwards, starting from the result. "We can see exactly where a certain group of neurons made a certain decision, and how strongly this decision impacted the result," says Samek. The researchers have already impressively demonstrated – multiple times – that the method works. For instance, they compared two programs that are publicly available on the Internet and that are both capable of recognizing horses in images. The result was surprising. The first program actually recognized the horses' bodies. The second one, however, focused on the copyright symbols on the photos, which pointed to forums for horse lovers, or riding and breeding associations, enabling the program to achieve a high success rate even though it had never learned what horses look like.

Applications in big data

"So you can see how important it is to understand exactly how such a network functions," says Samek. This knowledge is also of particular interest to industry. "It is conceivable, for instance, that the operating data of a complex production plant could be analyzed to deduce which parameters impact product quality or cause it to fluctuate," he says. The invention is also interesting for many other applications that involve the neural analysis of large or complex data volumes. "In another experiment, we were able to show which parameters a network uses to decide whether a face appears young or old."

According to Samek, for a long time banks have even been using neural networks to analyze bank customers' creditworthiness. To do this, large volumes of customer data are collected and evaluated by a neural network. "If we knew how the network reaches its decision, we could reduce the data volume right from the start by selecting the relevant parameters," he says. This would certainly be in the customers' interests, too. At the CeBIT trade fair in Hannover from March 20 to 24, 2017, Samek's team of researchers will demonstrate how they use their software to analyze the black boxes of neural networks – and how these networks can deduce a person's age or sex from their face, or recognize animals. [17]

New AI algorithm taught by humans learns beyond its training

"Hey Siri, how's my hair?" Your smartphone may soon be able to give you an honest answer, thanks to a new machine learning algorithm designed by U of T Engineering researchers Parham Aarabi and Wenzhi Guo.

The team designed an algorithm that learns directly from human instructions, rather than an existing set of examples, and outperformed conventional methods of training neural networks by 160 per cent. But more surprisingly, their algorithm also outperformed its own training by nine per cent—it learned to recognize hair in pictures with greater reliability than that enabled by the training, marking a significant leap forward for artificial intelligence.

Aarabi and Guo trained their algorithm to identify people's hair in photographs—a much more challenging task for computers than it is for humans.

"Our algorithm learned to correctly classify difficult, borderline cases—distinguishing the texture of hair versus the texture of the background," says Aarabi. "What we saw was like a teacher instructing a child, and the child learning beyond what the teacher taught her initially."

Humans "teach" neural networks—computer networks that learn dynamically—by providing a set of labeled data and asking the neural network to make decisions based on the samples it's seen. For example, you could train a neural network to identify sky in a photograph by showing it hundreds of pictures with the sky labeled.

This algorithm is different: it learns directly from human trainers. With this model, called heuristic training, humans provide direct instructions that are used to pre-classify training samples rather than a set of fixed examples. Trainers program the algorithm with guidelines such as "Sky is likely to be varying shades of blue," and "Pixels near the top of the image are more likely to be sky than pixels at the bottom."

Their work is published in the journal IEEE Transactions on Neural Networks and Learning Systems.

This heuristic training approach holds considerable promise for addressing one of the biggest challenges for neural networks: making correct classifications of previously unknown or unlabeled data. This is crucial for applying machine learning to new situations, such as correctly identifying cancerous tissues for medical diagnostics, or classifying all the objects surrounding and approaching a self-driving car.

"Applying heuristic training to hair segmentation is just a start," says Guo. "We're keen to apply our method to other fields and a range of applications, from medicine to transportation." [16]

Transforming, self-learning software could help save the planet

Artificially intelligent computer software that can learn, adapt and rebuild itself in real-time could help combat climate change.

Researchers at Lancaster University's Data Science Institute have developed a software system that can for the first time rapidly self-assemble into the most efficient form without needing humans to tell it what to do.

The system – called REx – is being developed with vast energy-hungry data centres in mind. By being able to rapidly adjust to optimally deal with a huge multitude of tasks, servers controlled by REx would need to do less processing, therefore consuming less energy.

REx works using 'micro-variation' – where a large library of building blocks of software components (such as memory caches, and different forms of search and sort algorithms) can be selected and assembled automatically in response to the task at hand.

"Everything is learned by the live system, assembling the required components and continually assessing their effectiveness in the situations to which the system is subjected," said Dr Barry Porter, lecturer at Lancaster University's School of Computing and Communications. "Each component is sufficiently small that it is easy to create natural behavioural variation. By autonomously assembling systems from these micro-variations we then see REx create software designs that are automatically formed to deal with their task.

"As we use connected devices on a more frequent basis, and as we move into the era of the Internet of Things, the volume of data that needs to be processed and distributed is rapidly growing. This is causing a significant demand for energy through millions of servers at data centres. An automated system like REx, able to find the best performance in any conditions, could offer a way to significantly reduce this energy demand," Dr Porter added.

In addition, as modern software systems are increasingly complex – consisting of millions of lines of code – they need to be maintained by large teams of software developers at significant cost. It is broadly acknowledged that this level of complexity and management is unsustainable. As well as saving energy in data centres, self-assembling software models could also have significant advantages by improving our ability to develop and maintain increasingly complex software systems for a wide range of domains, including operating systems and Internet infrastructure.

REx is built using three complementary layers. At the base level a novel component-based programming language called Dana enables the system to find, select and rapidly adapt the building blocks of software. A perception, assembly and learning framework (PAL) then configures and perceives the behaviour of the selected components, and an online learning process learns the best software compositions in real-time by taking advantage of statistical learning methods known as 'linear bandit models'. [15]

How quantum effects could improve artificial intelligence

Over the past few decades, quantum effects have greatly improved many areas of information science, including computing, cryptography, and secure communication. More recently, research has suggested that quantum effects could offer similar advantages for the emerging field of quantum machine learning (a subfield of artificial intelligence), leading to more intelligent machines that learn quickly and efficiently by interacting with their environments.

In a new study published in Physical Review Letters, Vedran Dunjko and coauthors have added to this research, showing that quantum effects can likely offer significant benefits to machine learning.

"The progress in machine learning critically relies on processing power," Dunjko, a physicist at the University of Innsbruck in Austria, told Phys.org. "Moreover, the type of underlying information processing that many aspects of machine learning rely upon is particularly amenable to quantum enhancements. As quantum technologies emerge, quantum machine learning will play an instrumental role in our society—including deepening our understanding of climate change, assisting in the development of new medicine and therapies, and also in settings relying on learning through interaction, which is vital in automated cars and smart factories."

In the new study, the researchers' main result is that quantum effects can help improve reinforcement learning, which is one of the three main branches of machine learning. They showed that quantum effects have the potential to provide quadratic improvements in learning efficiency, as well as exponential improvements in performance for short periods of time when compared to classical techniques for a wide class of learning problems.

While other research groups have previously shown that quantum effects can offer improvements for the other two main branches of machine learning (supervised and unsupervised learning), reinforcement learning has not been as widely investigated from a quantum perspective.

"This is, to our knowledge, the first work which shows that quantum improvements are possible in more general, interactive learning tasks," Dunjko said. "Thus, it opens up a new frontier of research in quantum machine learning."

One of the ways that quantum effects may improve machine learning is quantum superposition, which allows a machine to perform many steps simultaneously, improving the speed and efficiency at which it learns.

But while in certain situations quantum effects have the potential to offer great improvements, in other cases classical machine learning likely performs just as well or better than it would with quantum effects. Part of the reason for the difficulty in determining how quantum effects can improve machine learning is due to the unique set of challenges involved, beginning with the basic question of what it means to learn. Such a question becomes problematic, the scientists explain, since the machine and its environment may become entangled, blurring the boundary between the two.

Overall, the researchers expect that the systematic approach proposed here, which encompasses all three of the main branches of machine learning, will lead to the first steps in a complete theory of quantum-enhanced learning.

"While the initial results are very encouraging, we have only begun to investigate the potential of quantum machine learning," Dunjko said. "We plan on furthering our understanding of how quantum effects can aid in aspects of machine learning in an increasingly more general learning setting. One of the open questions we are interested in is whether quantum effects can play an instrumental role in the design of true artificial intelligence." [14]

First Demonstration Of Artificial Intelligence On A Quantum Computer

The advantage comes when one of those states represents a 1 and the other a 0, forming a quantum bit or qubit. In that case, a single quantum object — an atomic nucleus for example— can perform a calculation on two numbers at the same time. Two nuclei can handle 4 numbers, 3 nuclei 8 numbers and 20 nuclei can perform a calculation using more than a million numbers simultaneously. That's why even a relatively modest quantum computer could dramatically outperform the most advanced supercomputers today.

Quantum physicists have even demonstrated this using small quantum computers crunching a handful of qubits to carry out tasks such as finding the factors of numbers. That's the kind of calculation that, on a larger scale, could break the codes that currently encrypt top secret communications.

Now physicists have gone a step further. Today, Zhaokai Li and pals at the University of Science and Technology of China in Hefei demonstrate machine learning on a quantum computer for the first time. Their quantum computer can recognise handwritten characters, just as humans can do, in what Li and co are calling the first demonstration of "quantum artificial intelligence".

Machine learning begins with a set of data to train the device. The idea is to convert each image into a vector by analysing the number of image pixels in each part of the picture.

To keep the experiment simple, the team trained their machine to recognise the difference between a handwritten 6 and a handwritten 9. The vectors representing 6s and 9s can then be compared in this feature space to work out how best to distinguish between them. In effect, the computer finds a hyperplane in the feature space that separates the vectors representing 6s from those representing 9s.

That makes the task of recognising other 6s or 9s straightforward. For each new image of a character, the computer has to decide which side of the dividing line the vector sits.

A key measure of computing performance is the complexity of the problem — the way in which it scales, or takes longer to solve, as the problem gets bigger. The simplest problems are ones which scale in proportion to these variables. So it might take twice as long to process twice as many pictures. Computer scientists say these scale in linear time. Another relatively straightforward type of problem increases with the logarithm of the number of images; it scales in logarithmic time.

But in this case, the problem scales by a factor raised to the power of the number of images and dimensions. In other words, it scales in polynomial time. So as the number of dimensions and images increase, the time it takes to crunch the data increases dramatically.

That's why quantum computers can help. Last year, a team of quantum theorists devised a quantum algorithm that solves this kind of machine learning problem in logarithmic time rather than polynomial time. That's a vast speed up. However, their work was entirely theoretical.

It is this algorithm that Li and co have implemented on their quantum computer for the first time.

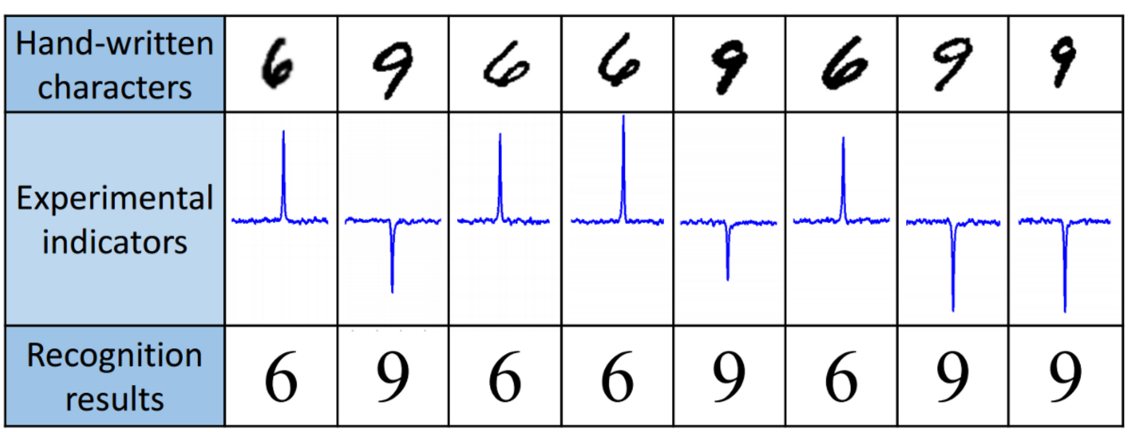
Their quantum computing machine consists of a small vat of the organic liquid carbon-13-iodotrifluroethylene, a molecule consisting of two carbon atoms attached to three fluorine atoms and one iodine atom. Crucially, one of the carbon atoms is a carbon-13 isotope.

This molecule is handy because each of the three fluorine atoms and the carbon-13 atom can store a single qubit. This works by placing the molecule in a magnetic field to align the spins of the nuclei and then flipping the spins with radio waves. Because each nucleus sits in a slightly different position in the molecule, each can be addressed by slightly different frequencies, a process known as nuclear magnetic resonance.

The spins can also be made to interact with each other so that the molecule acts like a tiny logic gate when zapped by a carefully prepared sequence of radio pulses. In this way the molecule processes data. And because the spins of each nucleus can exist in a superposition of spin up and spin down states, the molecule acts like a tiny quantum computer.

Having processed the quantum information, physicists read out the result by measuring the final states of all the atoms. Because the signal from each molecule is tiny, physicists need an entire vat of them to pick up the processed signal. In this case, an upward peak in the spectrum from the carnon-13 atom indicates the character is a 6 while a downward peak indicates a 9.

The results for the handwritten characters are shown below. "The successful classification shows the ability of our quantum machine to learn and work like an intelligent human," say Li and co.



That's an interesting result for artificial intelligence and more broadly for quantum computing. It demonstrates the potential for quantum computation, not just for character recognition, but for other kinds of big data challenges. "This work paves the way to a bright future where the Big Data is processed efficiently in a parallel way provided by quantum mechanics," say the team.

There are significant challenges ahead, of course. Not least of these is building more powerful quantum computers. The devices that rely on nuclear magnetic resonance cannot handle more than handful of qubits. [13]

Computer invents new scientific theory without human help for the first time

The mystery of how flatworms regenerate has been solved independently by a computer. (Max Delbrück Center)

One of biology's biggest mysteries - how a sliced up flatworm can regenerate into new organisms - has been solved independently by a computer. The discovery marks the first time that a computer has come up with a new scientific theory without direct human help.

Computer scientists from the University of Maryland programmed a computer to randomly predict how a worm's genes formed a regulatory network capable of regeneration, before evaluating these predictions through simulation.

Artificial intelligence flatworm discovery

The computer invented an accurate model of the inner-workings of a flatworm(UoM).

After three days of continuously predicting, simulating and evaluating, the computer was able to come up with a core genetic network that explained how the worm's regeneration took place.

The study by Daniel Lobo and Michael Levin, Inferring Regulatory Networks from Experimental Morphological Phenotypes, was published on Thursday (4 June) in the journal PLOS.

"It's not just statistics or number-crunching," Levin told Popular Mechanics. "The invention of models to explain what nature is doing is the most creative thing scientists do. This is the heart and soul of the scientific enterprise. None of us could have come up with this model; we (as a field) have failed to do so after over a century of effort."

Lobo and Levin are now applying the trial-and-error approach to creating scientific models and theories in different areas, including cancer research.

The pair believes that the approach can be used to better understand the process of metastasis, which causes cancer to spread through the body.

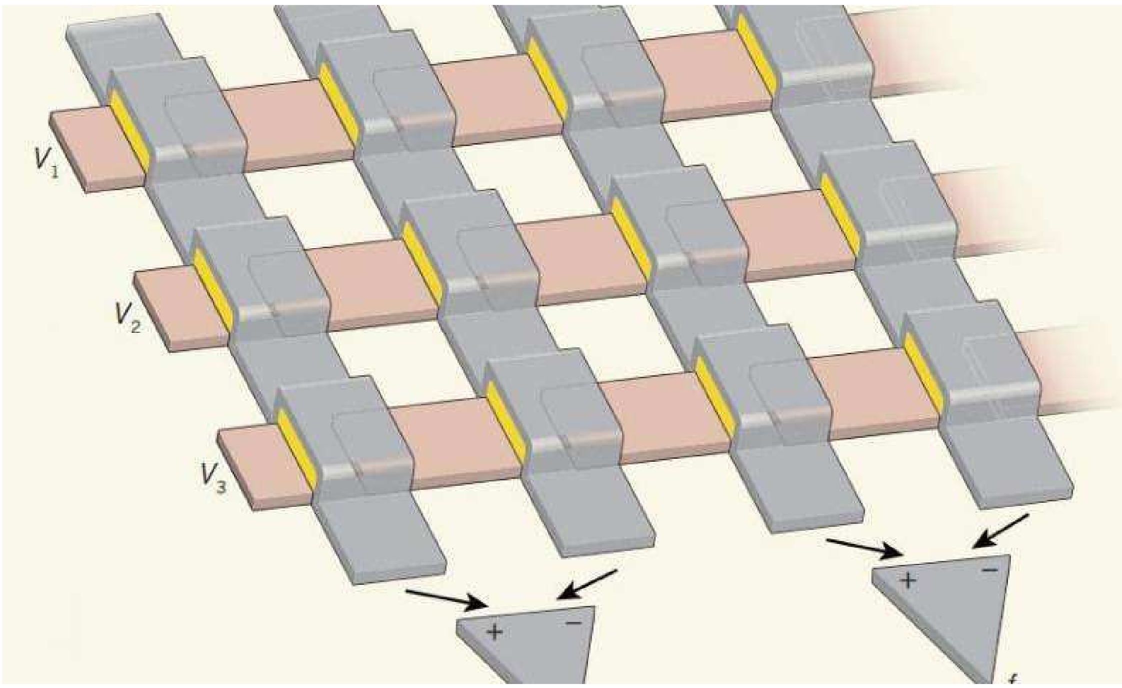
However, despite the computer only taking three days to create the worm model, it took the scientists several years to put together the program.

In order to transfer the computer's abilities to other areas, massive databases of scientific experiments would need to be prepared in order to have enough raw materials for discoveries to be made.

"This problem, and our approach, is nearly universal," Levin said. "It can be used with anything, where functional data exist but the underlying mechanism is hard to guess.

"As long as you tweak the formal language, build the database of facts in your field, and provide an appropriate simulator, the whole scheme can be used for many, man applications." [12]

Researchers create first neural-network chip built just with memristors



Memristors may sound like something from a sci-fi movie, but they actually exist—they are electronic analog memory devices that are modeled on human neurons and synapses. Human consciousness, some believe, is in reality, nothing more than an advanced form of memory retention and processing, and it is analog, as opposed to computers, which of course are digital. The idea for memristors was first dreamed up by University of California professor Leon Chua back in 1971, but it was not until a team working at Hewlett-Packard in 2008, first built one. Since then, a lot of research has gone into studying the technology, but until now, no one had ever built a neural-network chip based exclusively on them.

Up till now, most neural networks have been software based, Google, Facebook and IBM, for example, are all working on computer systems running such learning networks, mostly meant to pick faces out of a crowd, or return an answer based on a human phrased question. While the gains in such technology have been obvious, the limiting factor is the hardware—as neural networks grow in size and complexity, they begin to tax the abilities of even the fastest computers. The next step, most in the field believe, is to replace transistors with memristors—each on its own is able to learn, in ways similar to the way neurons in the brain learn when presented with something new. Putting them on a chip would of course reduce the overhead needed to run such a network.

The new chip, the team reports, was created using transistor-free metal-oxide memristor crossbars and represents a basic neural network able to perform just one task—to learn and recognize patterns in very simple 3 × 3-pixel black and white images. The experimental chip, they add, is an important step towards the creation of larger neural networks that tap the real power of memristors.
It also makes possible the idea of building computers in lock-step with advances in research looking into discovering just how exactly our neurons work at their most basic level.

Despite much progress in semiconductor integrated circuit technology, the extreme complexity of the human cerebral cortex, with its approximately 1014 synapses, makes the hardware implementation of neuromorphic networks with a comparable number of devices exceptionally challenging. To provide comparable complexity while operating much faster and with manageable power dissipation, networks based on circuits combining complementary metal-oxide-semiconductors (CMOSs) and adjustable two-terminal resistive devices (memristors) have been developed. In such circuits, the usual CMOS stack is augmented with one or several crossbar layers, with memristors at each crosspoint. There have recently been notable improvements in the fabrication of such memristive crossbars and their integration with CMOS circuits, including first demonstrations of their vertical integration. Separately, discrete memristors have been used as artificial synapses in neuromorphic networks. Very recently, such experiments have been extended to crossbar arrays of phase-change memristive devices. The adjustment of such devices, however, requires an additional transistor at each crosspoint, and hence these devices are much harder to scale than metal-oxide memristors, whose nonlinear current–voltage curves enable transistor-free operation. Here we report the experimental implementation of transistor-free metal-oxide memristor crossbars, with device variability sufficiently low to allow operation of integrated neural networks, in a simple network: a single-layer perceptron (an algorithm for linear classification). The network can be taught in situ using a coarse-grain variety of the delta rule algorithm to perform the perfect classification of 3 × 3-pixel black/white images into three classes (representing letters). This demonstration is an important step towards much larger and more complex memristive neuromorphic networks. [11]

Computers that mimic the function of the brain

Concept illustration (stock image). A new step forward in memristor technology could bring us closer to brain-like computing.

Researchers are always searching for improved technologies, but the most efficient computer possible already exists. It can learn and adapt without needing to be programmed or updated. It has nearly limitless memory, is difficult to crash, and works at extremely fast speeds. It's not a Mac or a PC; it's the human brain. And scientists around the world want to mimic its abilities.

Both academic and industrial laboratories are working to develop computers that operate more like the human brain. Instead of operating like a conventional, digital system, these new devices could potentially function more like a network of neurons.

"Computers are very impressive in many ways, but they're not equal to the mind," said Mark Hersam, the Bette and Neison Harris Chair in Teaching Excellence in Northwestern University's McCormick School of Engineering. "Neurons can achieve very complicated computation with very low power consumption compared to a digital computer."

A team of Northwestern researchers, including Hersam, has accomplished a new step forward in electronics that could bring brain-like computing closer to reality. The team's work advances memory resistors, or "memristors," which are resistors in a circuit that "remember" how much current has flowed through them.

The research is described in the April 6 issue of Nature Nanotechnology. Tobin Marks, the Vladimir N. Ipatieff Professor of Catalytic Chemistry, and Lincoln Lauhon, professor of materials science and engineering, are also authors on the paper. Vinod Sangwan, a postdoctoral fellow co-advised by Hersam, Marks, and Lauhon, served as first author. The remaining co-authors--Deep Jariwala, In Soo Kim, and Kan-Sheng Chen--are members of the Hersam, Marks, and/or Lauhon research groups.

"Memristors could be used as a memory element in an integrated circuit or computer," Hersam said. "Unlike other memories that exist today in modern electronics, memristors are stable and remember their state even if you lose power."

Current computers use random access memory (RAM), which moves very quickly as a user works but does not retain unsaved data if power is lost. Flash drives, on the other hand, store information when they are not powered but work much slower. Memristors could provide a memory that is the best of both worlds: fast and reliable. But there's a problem: memristors are two-terminal electronic devices, which can only control one voltage channel. Hersam wanted to transform it into a three-terminal device, allowing it to be used in more complex electronic circuits and systems.

Hersam and his team met this challenge by using single-layer molybdenum disulfide (MoS2), an atomically thin, two-dimensional nanomaterial semiconductor. Much like the way fibers are arranged in wood, atoms are arranged in a certain direction--called "grains"--within a material. The sheet of MoS2 that Hersam used has a well-defined grain boundary, which is the interface where two different grains come together.

"Because the atoms are not in the same orientation, there are unsatisfied chemical bonds at that interface," Hersam explained. "These grain boundaries influence the flow of current, so they can serve as a means of tuning resistance."

When a large electric field is applied, the grain boundary literally moves, causing a change in resistance. By using MoS2 with this grain boundary defect instead of the typical metal-oxide-metal memristor structure, the team presented a novel three-terminal memristive device that is widely tunable with a gate electrode. [10]

Fastest Operating System for Quantum Computing Developed By Researchers

Researchers have been working on significant activities to develop quantum computing technology that might enable the development of a Superfast quantum computer, though there has been less work done in the development of an Operating System that might control the quantum computers.

However, CQCL researchers have done just that and also believe that "Quantum computing will be a reality much earlier than originally anticipated. It will have profound and far-reaching effects on a vast number of aspects of our daily lives."

Polishing Quantum Computing:

CQCL's new operating system for the quantum computer comes just days after IBM researchers brought us even closer to a working Superfast quantum computer by discovering a new method for correcting two errors that a quantum computer can make.

One of the biggest issues that prevent us from developing Superfast Quantum Computers is — Quantum computing is incredibly fragile, and even the slightest fault can cause a major error to the computer.

However, IBM researchers have discovered a new way to detect both types of quantum computer errors, and revealed a new, square quantum bit circuit design that, according to them, can be easily scaled up to make high-performance computers, according to the details published in Nature Communications.

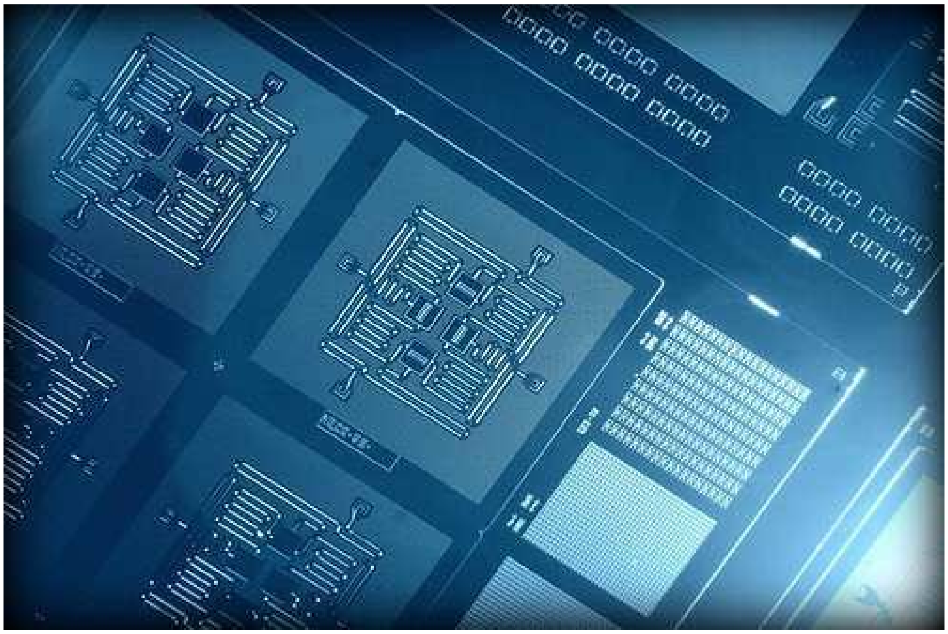
What's the difference between a Regular computer and a Quantum computer?

Traditional computers use the "bits" to represent information as a 0 or a 1; therefore they are so much slower. On the other hand, Quantum computers use "qubits" (quantum bits) to represent information as a 0, 1, or both at the same time.

But, the major problem with qubits is that they sometimes flip without warning. Qubits can suddenly flip from 0 to 1, which is called a bit flip, or from 0+1 to 0-1, which is called a phase flip. And these flipping are the actual culprits that creates all kinds of errors in a quantum computer.

Until now, scientists could only detect one error at a time. However, IBM's quantum circuit, consisting of four superconducting qubits on a one-quarter inch square chip, allowed researchers to detect bit-flip as well as phase-flip quantum errors simultaneously. [9]

Scientists achieve critical steps to building first practical quantum computer



Layout of IBM's four superconducting quantum bit device. Using a square lattice, IBM is able to detect both types of quantum errors for the first time. This is the best configuration to add more qubits to scale to larger systems.

With Moore's Law expected to run out of steam, quantum computing will be among the inventions that could usher in a new era of innovation across industries.
Quantum computers promise to open up new capabilities in the fields of optimization and simulation simply not possible using today's computers. If a quantum computer could be built with just 50 quantum bits (qubits), no combination of today's TOP500 supercomputers could successfully outperform it.

The IBM breakthroughs, described in the April 29 issue of the journal Nature Communications, show for the first time the ability to detect and measure the two types of quantum errors (bit-flip and phase-flip) that will occur in any real quantum computer. Until now, it was only possible to address one type of quantum error or the other, but never both at the same time. This is a necessary step toward quantum error correction, which is a critical requirement for building a practical and reliable large-scale quantum computer.

IBM's novel and complex quantum bit circuit, based on a square lattice of four superconducting qubits on a chip roughly one-quarter-inch square, enables both types of quantum errors to be detected at the same time. By opting for a square-shaped design versus a linear array – which prevents the detection of both kinds of quantum errors simultaneously – IBM's design shows the best potential to scale by adding more qubits to arrive at a working quantum system.

"Quantum computing could be potentially transformative, enabling us to solve problems that are impossible or impractical to solve today," said Arvind Krishna, senior vice president and director of IBM Research. "While quantum computers have traditionally been explored for cryptography, one area we find very compelling is the potential for practical quantum systems to solve problems in physics and quantum chemistry that are unsolvable today. This could have enormous potential in materials or drug design, opening up a new realm of applications."

For instance, in physics and chemistry, quantum computing could allow scientists to design new materials and drug compounds without expensive trial and error experiments in the lab, potentially speeding up the rate and pace of innovation across many industries.

For a world consumed by Big Data, quantum computers could quickly sort and curate ever larger databases as well as massive stores of diverse, unstructured data. This could transform how people make decisions and how researchers across industries make critical discoveries.

One of the great challenges for scientists seeking to harness the power of quantum computing is controlling or removing quantum decoherence – the creation of errors in calculations caused by interference from factors such as heat, electromagnetic radiation, and material defects. The errors are especially acute in quantum machines, since quantum information is so fragile.

"Up until now, researchers have been able to detect bit-flip or phase-flip quantum errors, but never the two together. Previous work in this area, using linear arrangements, only looked at bit-flip errors offering incomplete information on the quantum state of a system and making them inadequate for a quantum computer," said Jay Gambetta, a manager in the IBM Quantum Computing Group. "Our four qubit results take us past this hurdle by detecting both types of quantum errors and can be scalable to larger systems, as the qubits are arranged in a square lattice as opposed to a linear array."

The work at IBM was funded in part by the IARPA (Intelligence Advanced Research Projects Activity) multi-qubit-coherent-operations program.

Detecting quantum errors

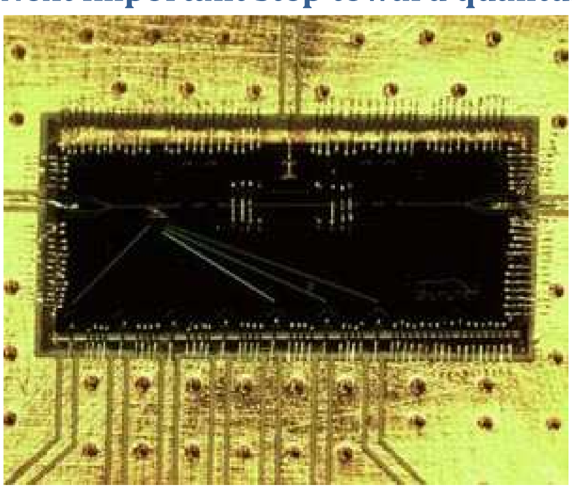
The most basic piece of information that a typical computer understands is a bit. Much like a beam of light that can be switched on or off, a bit can have only one of two values: "1" or "0". However, a quantum bit (qubit) can hold a value of 1 or 0 as well as both values at the same time, described as superposition and simply denoted as "0+1". The sign of this superposition is important because both states 0 and 1 have a phase relationship to each other. This superposition property is what allows quantum computers to choose the correct solution amongst millions of possibilities in a time much faster than a conventional computer.

Two types of errors can occur on such a superposition state. One is called a bit-flip error, which simply flips a 0 to a 1 and vice versa. This is similar to classical bit-flip errors and previous work has showed how to detect these errors on qubits. However, this is not sufficient for quantum error correction because phase-flip errors can also be present, which flip the sign of the phase relationship between 0 and 1 in a superposition state. Both types of errors must be detected in order for quantum error correction to function properly.

Quantum information is very fragile because all existing qubit technologies lose their information when interacting with matter and electromagnetic radiation.
Theorists have found ways to preserve the information much longer by spreading information across many physical qubits. "Surface code" is the technical name for a specific error correction scheme which spreads quantum information across many qubits. It allows for only nearest neighbor interactions to encode one logical qubit, making it sufficiently stable to perform error-free operations.

The IBM Research team used a variety of techniques to measure the states of two independent syndrome (measurement) qubits. Each reveals one aspect of the quantum information stored on two other qubits (called code, or data qubits). Specifically, one syndrome qubit revealed whether a bit-flip error occurred to either of the code qubits, while the other syndrome qubit revealed whether a phase-flip error occurred. Determining the joint quantum information in the code qubits is an essential step for quantum error correction because directly measuring the code qubits destroys the information contained within them. [8]

Next important step toward quantum computer



When facing big challenges, it is best to work together. In a team, the individual members can contribute their individual strengths - to the benefit of all those involved. One may be an absent-minded scientist who has brilliant ideas, but quickly forgets them. He needs the help of his conscientious colleague, who writes everything down, in order to remind the scatterbrain about it later. It's very similar in the world of quanta.

There the so-called quantum dots (abbreviated: qDots) play the role of the forgetful genius. Quantum dots are unbeatably fast, when it comes to disseminating quantum information. Unfortunately, they forget the result of the calculation just as quickly - too quickly to be of any real use in a quantum computer.

In contrast, charged atoms, called ions, have an excellent memory: They can store quantum information for many minutes. In the quantum world, that is an eternity.

They are less well suited for fast calculations, however, because the internal processes are comparatively slow.

The physicists from Bonn and Cambridge have therefore obliged both of these components, qDots and ions, to work together as a team. Experts speak of a hybrid system, because it combines two completely different quantum systems with one another.

Absent-minded qDots

qDots are considered the great hopes in the development of quantum computers. In principle, they are extremely miniaturized electron storage units. qDots can be produced using the same techniques as normal computer chips. To do so, it is only necessary to miniaturize the structures on the chips until they hold just one single electron (in a conventional PC it is 10 to 100 electrons).

The electron stored in a qDot can take on states that are predicted by quantum theory. However, they are very short-lived: They decay within a few picoseconds (for illustration: in one picosecond, light travels a distance of just 0.3 millimeters).

This decay produces a small flash of light: a photon. Photons are wave packets that vibrate in a specific plane - the direction of polarization. The state of the qDots determines the direction of polarization of the photon. "We used the photon to excite an ion", explains Prof. Dr. Michael Kohl from the Institute of Physics at the University of Bonn. "Then we stored the direction of polarization of the photon".

Conscientious ions

To do so, the researchers connected a thin glass fiber to the qDot. They transported the photon via the fiber to the ion many meters away. The fiberoptic networks used in telecommunications operate very similarly. To make the transfer of information as efficient as possible, they had trapped the ion between two mirrors. The mirrors bounced the photon back and forth like a ping pong ball, until it was absorbed by the ion.

"By shooting it with a laser beam, we were able to read out the ion that was excited in this way", explains Prof. Kohl. "In the process, we were able to measure the direction of polarization of the previously absorbed photon". In a sense then, the state of the qDot can be preserved in the ion - theoretically this can be done for many minutes. [7]

Quantum Computing

A team of electrical engineers at UNSW Australia has observed the unique quantum behavior of a pair of spins in silicon and designed a new method to use them for "2-bit" quantum logic operations.

These milestones bring researchers a step closer to building a quantum computer, which promises dramatic data processing improvements.

Quantum bits, or qubits, are the building blocks of quantum computers. While many ways to create a qubits exist, the Australian team has focused on the use of single atoms of phosphorus, embedded inside a silicon chip similar to those used in normal computers.

The first author on the experimental work, PhD student Juan Pablo Dehollain, recalls the first time he realized what he was looking at.

"We clearly saw these two distinct quantum states, but they behaved very differently from what we were used to with a single atom. We had a real 'Eureka!' moment when we realized what was happening – we were seeing in real time the `entangled' quantum states of a pair of atoms." [5]

Researchers have developed the first silicon quantum computer building blocks that can process data with more than 99 percent accuracy, overcoming a major hurdle in the race to develop reliable quantum computers.

Researchers from the University of New South Wales (UNSW) in Australia have achieved a huge breakthrough in quantum computing - they've created two kinds of silicon quantum bit, or qubits, the building blocks that make up any quantum computer, that are more than 99 percent accurate.

The postdoctoral researcher who was lead author on Morello's paper explained in the press release: "The phosphorus atom contains in fact two qubits: the electron, and the nucleus. With the nucleus in particular, we have achieved accuracy close to 99.99 percent. That means only one error for every 10,000 quantum operations."

Both the breakthroughs were achieved by embedding the atoms in a thin layer of specially purified silicon, which contains only the silicon-28 isotope. Naturally occurring silicon is magnetic and therefore disturbs the quantum bit, messing with the accuracy of its data processing, but silicon-28 is perfectly non-magnetic. [6]

Quantum Entanglement

Measurements of physical properties such as position, momentum, spin, polarization, etc. performed on entangled particles are found to be appropriately correlated. For example, if a pair of particles is generated in such a way that their total spin is known to be zero, and one particle is found to have clockwise spin on a certain axis, then the spin of the other particle, measured on the same axis, will be found to be counterclockwise. Because of the nature of quantum measurement, however, this behavior gives rise to effects that can appear paradoxical: any measurement of a property of a particle can be seen as acting on that particle (e.g. by collapsing a number of superimposed states); and in the case of entangled particles, such action must be on the entangled system as a whole. It thus appears that one particle of an entangled pair "knows" what measurement has been performed on the other, and with what outcome, even though there is no known means for such information to be communicated between the particles, which at the time of measurement may be separated by arbitrarily large distances. [4]

The Bridge

The accelerating electrons explain not only the Maxwell Equations and the Special Relativity, but the Heisenberg Uncertainty Relation, the wave particle duality and the electron's spin also, building the bridge between the Classical and Quantum Theories. [1]

Accelerating charges

The moving charges are self maintain the electromagnetic field locally, causing their movement and this is the result of their acceleration under the force of this field. In the classical physics the charges will distributed along the electric current so that the electric potential lowering along the current, by linearly increasing the way they take every next time period because this accelerated motion.
The same thing happens on the atomic scale giving a dp impulse difference and a dx way difference between the different part of the not point like particles.

Relativistic effect

Another bridge between the classical and quantum mechanics in the realm of relativity is that the charge distribution is lowering in the reference frame of the accelerating charges linearly: ds/dt = at (time coordinate), but in the reference frame of the current it is parabolic: $s = a/2\ t^2$ (geometric coordinate).

Heisenberg Uncertainty Relation

In the atomic scale the Heisenberg uncertainty relation gives the same result, since the moving electron in the atom accelerating in the electric field of the proton, causing a charge distribution on delta x position difference and with a delta p momentum difference such a way that they product is about the half Planck reduced constant. For the proton this delta x much less in the nucleon, than in the orbit of the electron in the atom, the delta p is much higher because of the greater proton mass.

This means that the electron and proton are not point like particles, but has a real charge distribution.

Wave – Particle Duality

The accelerating electrons explains the wave – particle duality of the electrons and photons, since the elementary charges are distributed on delta x position with delta p impulse and creating a wave packet of the electron. The photon gives the electromagnetic particle of the mediating force of the electrons electromagnetic field with the same distribution of wavelengths.

Atomic model

The constantly accelerating electron in the Hydrogen atom is moving on the equipotential line of the proton and it's kinetic and potential energy will be constant. Its energy will change only when it is changing its way to another equipotential line with another value of potential energy or getting free with enough kinetic energy. This means that the Rutherford-Bohr atomic model is right and only that changing acceleration of the electric charge causes radiation, not the steady acceleration. The steady acceleration of the charges only creates a centric parabolic steady electric field around the charge, the magnetic field. This gives the magnetic moment of the atoms, summing up the proton and electron magnetic moments caused by their circular motions and spins.

The Relativistic Bridge

Commonly accepted idea that the relativistic effect on the particle physics it is the fermions' spin - another unresolved problem in the classical concepts. If the electric charges can move only with accelerated motions in the self maintaining electromagnetic field, once upon a time they would reach the velocity of the electromagnetic field. The resolution of this problem is the spinning particle, constantly accelerating and not reaching the velocity of light because the acceleration is radial. One origin of the Quantum Physics is the Planck Distribution Law of the electromagnetic oscillators, giving equal intensity for 2 different wavelengths on any temperature. Any of these two wavelengths will give equal intensity diffraction patterns, building different asymmetric constructions, for example proton - electron structures (atoms), molecules, etc. Since the particles are centers of diffraction patterns they also have particle – wave duality as the electromagnetic waves have. [2]

The weak interaction

The weak interaction transforms an electric charge in the diffraction pattern from one side to the other side, causing an electric dipole momentum change, which violates the CP and time reversal symmetry. The Electroweak Interaction shows that the Weak Interaction is basically electromagnetic in nature. The arrow of time shows the entropy grows by changing the temperature dependent diffraction patterns of the electromagnetic oscillators.

Another important issue of the quark model is when one quark changes its flavor such that a linear oscillation transforms into plane oscillation or vice versa, changing the charge value with 1 or -1. This kind of change in the oscillation mode requires not only parity change, but also charge and time changes (CPT symmetry) resulting a right handed anti-neutrino or a left handed neutrino.

The right handed anti-neutrino and the left handed neutrino exist only because changing back the quark flavor could happen only in reverse, because they are different geometrical constructions, the u is 2 dimensional and positively charged and the d is 1 dimensional and negatively charged. It needs also a time reversal, because anti particle (anti neutrino) is involved.

The neutrino is a 1/2spin creator particle to make equal the spins of the weak interaction, for example neutron decay to 2 fermions, every particle is fermions with ½ spin. The weak interaction changes the entropy since more or less particles will give more or less freedom of movement. The entropy change is a result of temperature change and breaks the equality of oscillator diffraction intensity of the Maxwell–Boltzmann statistics. This way it changes the time coordinate measure and makes possible a different time dilation as of the special relativity.

The limit of the velocity of particles as the speed of light appropriate only for electrical charged particles, since the accelerated charges are self maintaining locally the accelerating electric force. The neutrinos are CP symmetry breaking particles compensated by time in the CPT symmetry, that is the time coordinate not works as in the electromagnetic interactions, consequently the speed of neutrinos is not limited by the speed of light.

The weak interaction T-asymmetry is in conjunction with the T-asymmetry of the second law of thermodynamics, meaning that locally lowering entropy (on extremely high temperature) causes the weak interaction, for example the Hydrogen fusion.

Probably because it is a spin creating movement changing linear oscillation to 2 dimensional oscillation by changing d to u quark and creating anti neutrino going back in time relative to the proton and electron created from the neutron, it seems that the anti neutrino fastest then the velocity of the photons created also in this weak interaction?

A quark flavor changing shows that it is a reflection changes movement and the CP- and T- symmetry breaking!!! This flavor changing oscillation could prove that it could be also on higher level such as atoms, molecules, probably big biological significant molecules and responsible on the aging of the life.

Important to mention that the weak interaction is always contains particles and antiparticles, where the neutrinos (antineutrinos) present the opposite side. It means by Feynman's interpretation that these particles present the backward time and probably because this they seem to move faster than the speed of light in the reference frame of the other side.

Finally since the weak interaction is an electric dipole change with ½ spin creating; it is limited by the velocity of the electromagnetic wave, so the neutrino's velocity cannot exceed the velocity of light.

The General Weak Interaction

The Weak Interactions T-asymmetry is in conjunction with the T-asymmetry of the Second Law of Thermodynamics, meaning that locally lowering entropy (on extremely high temperature) causes for example the Hydrogen fusion. The arrow of time by the Second Law of Thermodynamics shows the increasing entropy and decreasing information by the Weak Interaction, changing the temperature dependent diffraction patterns. A good example of this is the neutron decay, creating more particles with less known information about them.

The neutrino oscillation of the Weak Interaction shows that it is a general electric dipole change and it is possible to any other temperature dependent entropy and information changing diffraction pattern of atoms, molecules and even complicated biological living structures.

We can generalize the weak interaction on all of the decaying matter constructions, even on the biological too. This gives the limited lifetime for the biological constructions also by the arrow of time. There should be a new research space of the Quantum Information Science the 'general neutrino oscillation' for the greater then subatomic matter structures as an electric dipole change.

There is also connection between statistical physics and evolutionary biology, since the arrow of time is working in the biological evolution also.
The Fluctuation Theorem says that there is a probability that entropy will flow in a direction opposite to that dictated by the Second Law of Thermodynamics. In this case the Information is growing that is the matter formulas are emerging from the chaos. So the Weak Interaction has two directions, samples for one direction is the Neutron decay, and Hydrogen fusion is the opposite direction.

Fermions and Bosons

The fermions are the diffraction patterns of the bosons such a way that they are both sides of the same thing.

Van Der Waals force

Named after the Dutch scientist Johannes Diderik van der Waals – who first proposed it in 1873 to explain the behaviour of gases – it is a very weak force that only becomes relevant when atoms and molecules are very close together. Fluctuations in the electronic cloud of an atom mean that it will have an instantaneous dipole moment. This can induce a dipole moment in a nearby atom, the result being an attractive dipole–dipole interaction.

Electromagnetic inertia and mass

Electromagnetic Induction

Since the magnetic induction creates a negative electric field as a result of the changing acceleration, it works as an electromagnetic inertia, causing an electromagnetic mass. [1]

Relativistic change of mass

The increasing mass of the electric charges the result of the increasing inductive electric force acting against the accelerating force. The decreasing mass of the decreasing acceleration is the result of the inductive electric force acting against the decreasing force. This is the relativistic mass change explanation, especially importantly explaining the mass reduction in case of velocity decrease.

The frequency dependence of mass

Since $E = hv$ and $E = mc^2$, $m = hv / c^2$ that is the m depends only on the v frequency. It means that the mass of the proton and electron are electromagnetic and the result of the electromagnetic induction, caused by the changing acceleration of the spinning and moving charge! It could be that the m_o inertial mass is the result of the spin, since this is the only accelerating motion of the electric charge. Since the accelerating motion has different frequency for the electron in the atom and the proton, they masses are different, also as the wavelengths on both sides of the diffraction pattern, giving equal intensity of radiation.

Electron – Proton mass rate

The Planck distribution law explains the different frequencies of the proton and electron, giving equal intensity to different lambda wavelengths! Also since the particles are diffraction patterns they have some closeness to each other – can be seen as a gravitational force. [2]

There is an asymmetry between the mass of the electric charges, for example proton and electron, can understood by the asymmetrical Planck Distribution Law. This temperature dependent energy distribution is asymmetric around the maximum intensity, where the annihilation of matter and antimatter is a high probability event. The asymmetric sides are creating different frequencies of electromagnetic radiations being in the same intensity level and compensating each other. One of these compensating ratios is the electron – proton mass ratio. The lower energy side has no compensating intensity level, it is the dark energy and the corresponding matter is the dark matter.

Gravity from the point of view of quantum physics

The Gravitational force

The gravitational attractive force is basically a magnetic force.

The same electric charges can attract one another by the magnetic force if they are moving parallel in the same direction. Since the electrically neutral matter is composed of negative and positive charges they need 2 photons to mediate this attractive force, one per charges. The Bing Bang caused parallel moving of the matter gives this magnetic force, experienced as gravitational force.

Since graviton is a tensor field, it has spin = 2, could be 2 photons with spin = 1 together.

You can think about photons as virtual electron – positron pairs, obtaining the necessary virtual mass for gravity.

The mass as seen before a result of the diffraction, for example the proton – electron mass rate Mp=1840 Me. In order to move one of these diffraction maximum (electron or proton) we need to intervene into the diffraction pattern with a force appropriate to the intensity of this diffraction maximum, means its intensity or mass.

The Big Bang caused acceleration created radial currents of the matter, and since the matter is composed of negative and positive charges, these currents are creating magnetic field and attracting forces between the parallel moving electric currents. This is the gravitational force experienced by the matter, and also the mass is result of the electromagnetic forces between the charged particles. The positive and negative charged currents attracts each other or by the magnetic forces or by the much stronger electrostatic forces!?

The gravitational force attracting the matter, causing concentration of the matter in a small space and leaving much space with low matter concentration: dark matter and energy.

There is an asymmetry between the mass of the electric charges, for example proton and electron, can understood by the asymmetrical Planck Distribution Law. This temperature dependent energy distribution is asymmetric around the maximum intensity, where the annihilation of matter and antimatter is a high probability event. The asymmetric sides are creating different frequencies of electromagnetic radiations being in the same intensity level and compensating each other. One of these compensating ratios is the electron – proton mass ratio. The lower energy side has no compensating intensity level, it is the dark energy and the corresponding matter is the dark matter.

The Higgs boson

By March 2013, the particle had been proven to behave, interact and decay in many of the expected ways predicted by the Standard Model, and was also tentatively confirmed to have + parity and zero spin, two fundamental criteria of a Higgs boson, making it also the first known scalar particle to be discovered in nature, although a number of other properties were not fully proven and some partial results do not yet precisely match those expected; in some cases data is also still awaited or being analyzed.

Since the Higgs boson is necessary to the W and Z bosons, the dipole change of the Weak interaction and the change in the magnetic effect caused gravitation must be conducted. The Wien law is also important to explain the Weak interaction, since it describes the T_{max} change and the diffraction patterns change. [2]

Higgs mechanism and Quantum Gravity

The magnetic induction creates a negative electric field, causing an electromagnetic inertia. Probably it is the mysterious Higgs field giving mass to the charged particles? We can think about the photon as an electron-positron pair, they have mass. The neutral particles are built from negative and positive charges, for example the neutron, decaying to proton and electron. The wave – particle duality makes sure that the particles are oscillating and creating magnetic induction as an inertial mass, explaining also the relativistic mass change. Higher frequency creates stronger magnetic induction, smaller frequency results lesser magnetic induction. It seems to me that the magnetic induction is the secret of the Higgs field.

In particle physics, the Higgs mechanism is a kind of mass generation mechanism, a process that gives mass to elementary particles. According to this theory, particles gain mass by interacting with the Higgs field that permeates all space. More precisely, the Higgs mechanism endows gauge bosons in a gauge theory with mass through absorption of Nambu–Goldstone bosons arising in spontaneous symmetry breaking.

The simplest implementation of the mechanism adds an extra Higgs field to the gauge theory. The spontaneous symmetry breaking of the underlying local symmetry triggers conversion of components of this Higgs field to Goldstone bosons which interact with (at least some of) the other fields in the theory, so as to produce mass terms for (at least some of) the gauge bosons. This mechanism may also leave behind elementary scalar (spin-0) particles, known as Higgs bosons.

In the Standard Model, the phrase "Higgs mechanism" refers specifically to the generation of masses for the $W^{\pm}$, and Z weak gauge bosons through electroweak symmetry breaking. The Large Hadron Collider at CERN announced results consistent with the Higgs particle on July 4, 2012 but stressed that further testing is needed to confirm the Standard Model.

What is the Spin?

So we know already that the new particle has spin zero or spin two and we could tell which one if we could detect the polarizations of the photons produced. Unfortunately this is difficult and neither ATLAS nor CMS are able to measure polarizations. The only direct and sure way to confirm that the particle is indeed a scalar is to plot the angular distribution of the photons in the rest frame of the centre of mass. A spin zero particles like the Higgs carries no directional information away from the original collision so the distribution will be even in all directions. This test will be possible when a much larger number of events have been observed. In the mean time we can settle for less certain indirect indicators.

The Graviton

In physics, the graviton is a hypothetical elementary particle that mediates the force of gravitation in the framework of quantum field theory. If it exists, the graviton is expected to be massless (because the gravitational force appears to have unlimited range) and must be a spin-2 boson. The spin follows from the fact that the source of gravitation is the stress-energy tensor, a second-rank tensor (compared to electromagnetism's spin-1 photon, the source of which is the four-current, a first-rank tensor). Additionally, it can be shown that any massless spin-2 field would give rise to a force indistinguishable from gravitation, because a massless spin-2 field must couple to (interact with) the stress-energy tensor in the same way that the gravitational field does. This result suggests that, if a massless spin-2 particle is discovered, it must be the graviton, so that the only experimental verification needed for the graviton may simply be the discovery of a massless spin-2 particle. [3]

Conclusions

So physicists are racing to build quantum computers that can handle significantly more qubits. This is a race with fame and fortune at the end of it. There is no shortage of runners and the team that pulls it off will find an important place in the history of computing and physics in general.

With a few hundred qubits, who knows what quantum artificial intelligence could do. [13]

In order to transfer the computer's abilities to other areas, massive databases of scientific experiments would need to be prepared in order to have enough raw material for discoveries to be made. [12]

"With a memristor that can be tuned with a third electrode, we have the possibility to realize a function you could not previously achieve," Hersam said. "A three-terminal memristor has been proposed as a means of realizing brain-like computing. We are now actively exploring this possibility in the laboratory." [10]

"CQCL is at the forefront of developing an operating system that will allow users to harness the joint power of classical super computers alongside quantum computers," the company said in a press release. [9]

Because these qubits can be designed and manufactured using standard silicon fabrication techniques, IBM anticipates that once a handful of superconducting qubits can be manufactured reliably and repeatedly, and controlled with low error rates, there will be no fundamental obstacle to demonstrating error correction in larger lattices of qubits. [8]

This success is an important step on the still long and rocky road to a quantum computer. In the long term, researchers around the world are hoping for true marvels from this new type of computer: Certain tasks, such as the factoring of large numbers, should be child's play for such a computer. In contrast, conventional computers find this a really tough nut to crack. However, a quantum computer displays its talents only for such special tasks: For normal types of basic computations, it is pitifully slow. [7]

One of the most important conclusions is that the electric charges are moving in an accelerated way and even if their velocity is constant, they have an intrinsic acceleration anyway, the so called spin, since they need at least an intrinsic acceleration to make possible they movement .

The accelerated charges self-maintaining potential shows the locality of the relativity, working on the quantum level also. [1]

The bridge between the classical and quantum theory is based on this intrinsic acceleration of the spin, explaining also the Heisenberg Uncertainty Principle. The particle – wave duality of the electric charges and the photon makes certain that they are both sides of the same thing.

The Secret of Quantum Entanglement that the particles are diffraction patterns of the electromagnetic waves and this way their quantum states every time is the result of the quantum state of the intermediate electromagnetic waves. [2]
The key breakthrough to arrive at this new idea to build qubits was to exploit the ability to control the nuclear spin of each atom. With that insight, the team has now conceived a unique way to use the nuclei as facilitators for the quantum logic operation between the electrons. [5]
Basing the gravitational force on the accelerating Universe caused magnetic force and the Planck Distribution Law of the electromagnetic waves caused diffraction gives us the basis to build a Unified Theory of the physical interactions also.

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