Improving time resolution of CryoEM with laser

Cryoelectron microscopy is a method that can capture pictures of biomolecules such as proteins with atomic precision. The technique involves flash-freezing solutions of proteins or other biomolecules and then bombarding them with electrons to produce microscope images of individual molecules.

The cryo em microscope has opened the door for new dimensions in life sciences, chemistry, and medicine. Recently, it was used to map the structure of the SARS-CoV-2 spike protein, which is the target of many of the COVID-19 vaccines. The structure of proteins in the cell changes constantly. This constant rearrangement of proteins is essential to perform their specialized functions. Surprisingly, this process happens too fast to be observed in real-time by current cryoEM protocols, rendering our understanding of proteins incomplete. Now, scientists at EPFL have come up with a new method that can speed up the real-time observation capabilities of cryo-electron microscopy. The technique can capture images of protein movements at the microsecond (a millionth of a second) timescale. This new method involves the use of a laser to melt the vitrified sample rapidly. After melting of ice, there is enough time to induce protein for the movement in the way they do in their natural liquid state in the cell. Ulrich Lorenz at EPFL's School of Basic Sciences said, "Generally speaking, warming up a cryo sample causes it to de-vitrify. But we can overcome this obstacle by how quickly we melt the sample." The laser pulse re-vitrified the sample in just a few microseconds. It also trapped the articles in their transient ways. In this "paused" state, they can now be observed with conventional cryoEM methods. Lorenz said, "Matching the time resolution of cryoEM to the natural timescale of proteins will allow us to study processes that were previously inaccessible directly."

Representing robotic manipulator using a novel method

Adequate biomimicry is a practice in which robots learn from and mimics humans to make machines more like humans. Developing such a robotic manipulator is time-consuming: It includes long, manual iteration cycles of designing, fabricating, and evaluating guided by human intuition. Most of the robotic hands are designed for performing specific tasks. These hands have a high number of degrees of freedom and a complex control system. Although creating such hands is a tedious process. Existing methods battle the trade-off between the complexity of the designs and the practical constraints of manufacturing and contact handling.

To optimize the shape and control of a robotic manipulator for a specific task, a new method has been designed by MIT scientists that acts as an end-to-end differentiable framework for contact-aware robot design. Scientists created a single robotic finger design to flip over a box on the ground for testing their method. An algorithm optimized the mechanical finger to hook onto the box's back surface and flip it. In addition to that, a model was created for the assembly task. In this model, a two-finger design put a small cube into a larger, movable mount. Because of the different lengths of the fingers, the larger and flatter surfaces of the fingers helped stably push the object. Furthermore, a technique called 'cage-based deformation' was used to create more involved robot manipulators. The method allows the user to change or deform the shape in the meantime. The team developed a simulator to simulate the manipulator design and control on a task, providing a performance score. Jie Xu, MIT Ph.D. student and lead author on a new paper about the research, said, "Using these simulation tools, we don't need to evaluate the design by manufacturing and testing it in the real world. In contrast to reinforcement learning algorithms that are popular for manipulation but are data-inefficient, the proposed cage-based representation and the simulator allow for the use of powerful gradient-based methods. We not only find better solutions but also find them faster. As a result, we can quickly score the design, thus significantly shortening the design cycle." **—Agencies**

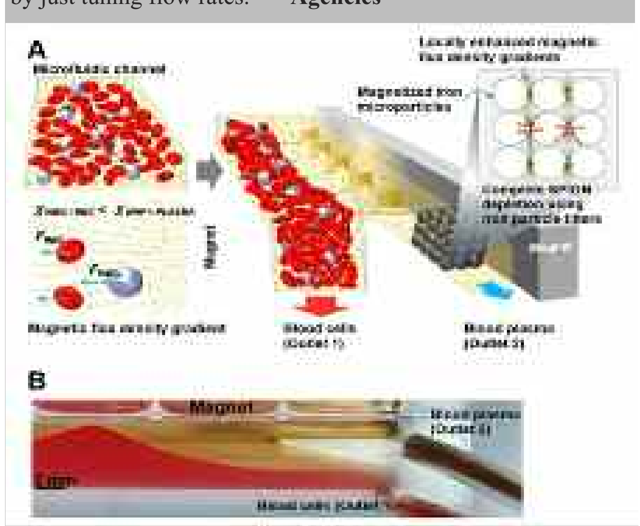
New technology for plasma separation using magnets

The new technology will greatly improve the accuracy of point-of-care blood tests

Scientists from UNIST have come up with a novel technology for plasma separation from blood. This new plasma separation technology could significantly enhance the accuracy of point-of-care blood tests, which has shown the increased demand recently. Using diamagnetic repulsion of blood cells, scientists were able to separate blood cells and blood plasma. In this method, the superparamagnetic iron oxide nanoparticles (SPIONs) are supplemented to whole blood. Once supplemented, the SPIONs turn the blood plasma into a paramagnetic condition, repelling all blood cells by magnets. Using the technology, scientists were able to collect hemolysis-free plasma without losing plasma proteins, platelets, and exosomes.

Professor Joo H. Kang said, "Many efforts have been made to develop various blood plasma separation methods. However, there always have been limitations, such as dilution of blood, blood cell impurity in plasma, and hemolysis. Our approach overcame these unmet challenges, and we could provide a huge impact on in vitro diagnosis once this platform is translated into a commercial point-of-care device." Interestingly, the technology achieved 100% of the plasma purity and 83.3% of the plasma volume recovery rate. Moreover, it enabled the greater recovery of bacterial DNA from the infected blood than centrifugation and immunoassays in whole blood without prior plasma separation.

Research Professor Seyong Kwon in the Department of Biomedical Engineering at UNIST said, "We have overcome the limitations of a filter-based blood plasma separation method that potentially could induce hemolysis or a microfluidic chip-based plasma separation method that has the problems in a plasma recovery rate and purity." The essential characteristic of this new method is it allows to the collection of platelet-rich plasma (PRP). This acts as a significant feature as recent studies suggest that platelets could be used as a biomarker to diagnose cancer or diabetes. Jieung Oh, the first co-author of the study, said, "Unlike a complex process of the conventional centrifugation method to collect PRP, our method can simply collect PRP by just tuning flow rates." **—Agencies**



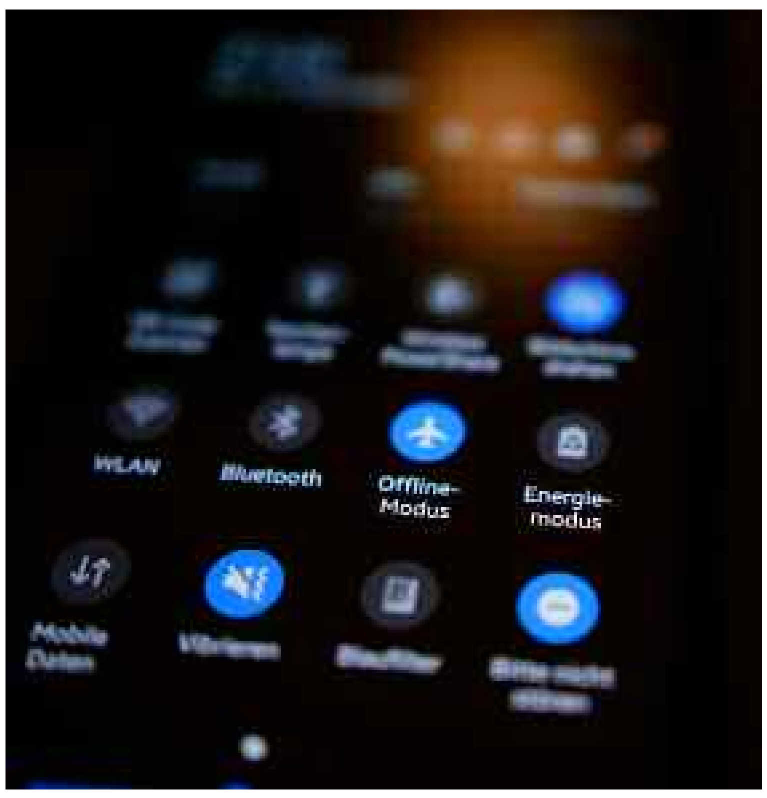
Phone's dark mode doesn't necessarily save much battery life

When Android and Apple operating system updates started giving users the option to put their smartphones in dark mode, the feature showed potential for saving the battery life of newer phones with screens that allow darker-colored pixels to use less power than lighter-colored pixels.

But dark mode is unlikely to make a big difference to battery life with the way that most people use their phones on a daily basis, says a new study by Purdue University researchers. That doesn't mean that dark mode can't be helpful, though.

"When the industry rushed to adopt dark mode, it didn't have the tools yet to accurately measure power draw by the pixels," said Charlie Hu, Purdue's Michael and Katherine Birck Professor of Electrical and Computer Engineering. "But now we're able to give developers the tools they need to give users more energy-efficient apps." Based on their findings using these tools they built, the researchers clarify the facts about the effects of dark mode on battery life and recommend ways that users can already take better advantage of the feature's power savings. The study looked at six of the most-downloaded apps on Google Play: Google Maps, Google News, Google Phone, Google Calendar, YouTube, and Calculator. The researchers analyzed how dark mode affects 60 seconds of activity within each of these apps on the Pixel 2, Moto Z3, Pixel 4 and Pixel 5.

Even though Hu's team studied only Android apps and phones, their findings might have similar implications for Apple phones, starting with the iPhone X. The team recently presented this work at MobiSys 2021, a conference by the Association for Computing Machinery. Smartphones that came out after 2017 likely have an OLED (organic light-emitting diode) screen. Because this type of screen doesn't have a backlight like the LCD (liquid crystal display) screens of older phones, the screen will draw less power when displaying dark-colored pixels. OLED displays also allow phone screens to be ultra-thin, flexible and foldable.



But the brightness of OLED screens largely determines how much dark mode saves battery life, said Hu, who has been researching ways to improve the energy efficiency of smartphones since they first hit the market over a decade ago. The software tools that Hu and his team have developed are based on new patent-pending power modeling technology they invented to more accurately estimate the power draw of OLED phone displays. Many people use their phone's default auto-brightness setting, which tends to keep brightness levels around 30%-40% most of the time when indoors. At 30%-50% brightness, Purdue researchers found that switching from light mode to dark mode saves only 3%-9% power on average for several different OLED smartphones.

This percentage is so small that most users wouldn't notice the slightly longer battery life. But the higher the brightness when switching from light mode to dark mode, the higher the energy savings. Let's say that you're using your OLED phone in light mode while sitting outside watching a baseball game on a bright and sunny day. If your phone is set to automatically adjust brightness levels, then the screen has probably become really bright, which drains battery life.

The Purdue study found that switching from light mode to dark mode at 100% brightness saves an average of 39%-47% battery power. So turning on dark mode while your phone's screen is that bright could allow your phone to last a lot longer than if you had stayed in light mode. Other tests done by the industry haven't analyzed as many apps or phones as Hu's team did to determine the effects of dark mode on battery life – and they were using less accurate methods. "Tests done in the past to compare the effects of light mode with dark mode on battery life have treated the phone as a black box, lumping in OLED display with the phone's other gazillion components. Our tool can accurately isolate the portion of battery drain by the OLED display," said Pranab Dash, a Purdue Ph.D. student who worked with Hu on the study. Typically, increasing your phone's brightness drains its battery faster – no matter if you are in light mode or dark mode. But since conducting this study, Dash has collected data indicating that lower brightness levels in light mode result in the same power draw as higher brightness levels in dark mode. Using the Google News app in light mode at 20% brightness on the Pixel 5, for example, draws the same amount of power as when the phone is at 50% brightness in dark mode.

So if looking at your phone in dark mode is easier on your eyes, but you need the higher brightness to see better, you don't have to worry about this brightness level taking more of a toll on your phone's battery life. Hu and his team built a tool that app developers can use to determine the energy savings of a certain activity in dark mode as they design an app. The tool, called a Per-Frame OLED Power Profiler (PFOP), is based on the more accurate OLED power model that the team developed. The Purdue Research Foundation Office of Technology Commercialization has applied for a patent on this power modeling technology. Both PFOP and the power modeling technology are available for licensing. Both Android and Apple phones come with a way to look at how much battery power each individual app is consuming. You can access this feature in the settings of Android and Apple phones. The feature can give you a rough idea of the most power-hungry apps, but Hu and Dash found that Android's current "Battery" feature is oblivious to content on a screen, meaning it doesn't consider the impact of dark mode on power consumption. Hu's team has developed a more accurate way to calculate battery consumption by the app for Android, and actually used the tool to make the study's findings about how much power dark mode saves at certain brightness levels. Unlike Android's current feature, this new tool takes into account the effects of dark mode on battery life. The tool, called Android Battery+, is expected to become available to platform vendors and app developers in the coming year. **—Agencies**

Optimizing particle accelerator performance

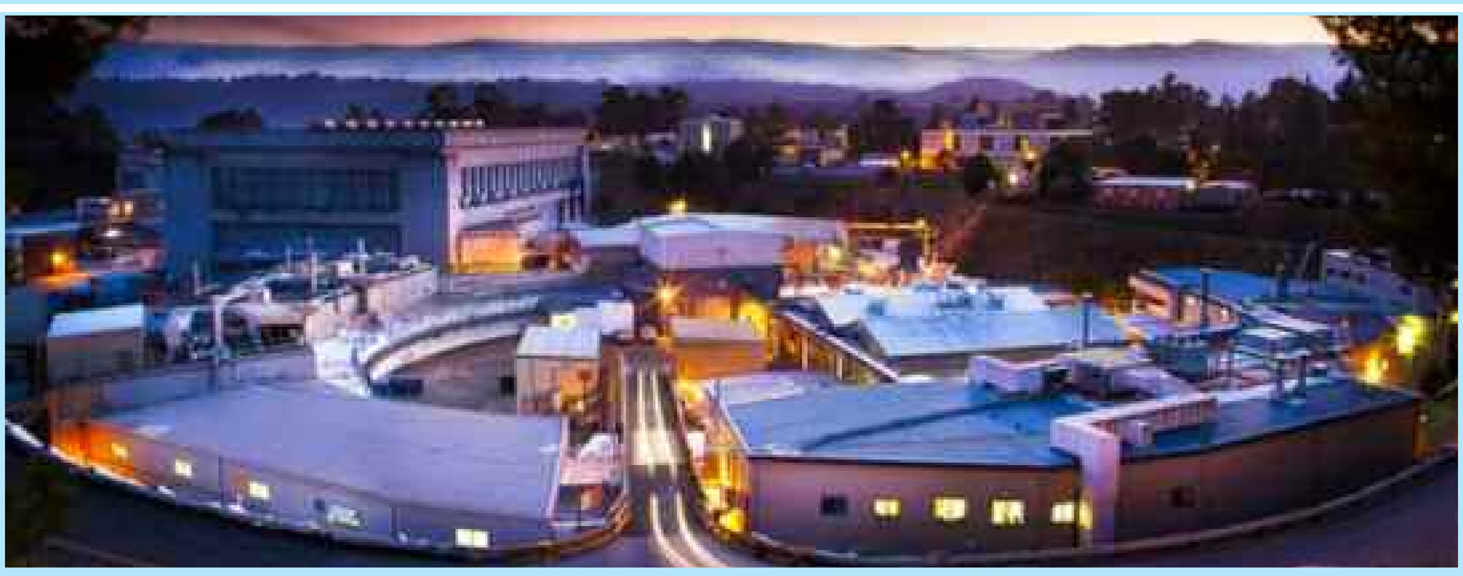
Teaching machine learning the basics of accelerator physics is particularly useful in situations where actual data don't exist.

Particle accelerators such as the Large Hadron Collider (LHC) propels charged particles, such as protons or electrons, at high speeds, close to the speed of light. Accelerated to a rate close to that of light, they energize the beam of other particles for use in a wide range of applications, including fundamental physics experiments, molecular imaging, and radiation therapy for cancer.

Operators need to tune up the accelerators for peak performance continuously. But, large particle accelerators are quite difficult to tune up as there are so many components equipped that need to be adjusted. Also, some components rely on each other to work properly. Hence, when you adjust one, it can affect the settings for another.

A recent study at SLAC come out with a solution. It suggests that machine learning can significantly enhance the performance of particle accelerators. Teaching machine learning the basics of accelerator physics is handy in situations where actual data don't exist. Adi Hanuka, a former SLAC research associate, said, "Injecting physics into machine learning is a really hot topic in many research areas – in materials science, environmental science, battery research, particle physics, and more." The benefits of injecting physics into machine learning are: It can support human operators by speeding up the optimization process and finding useful accelerator settings. Unlike other techniques, it can help diagnose the quality of particle beams without interfering with them. To make these things possible, scientists trained the machine learning algorithms with data from previous accelerator operations and computer simulations that make assumptions about the accelerator's performance. It was also found that using data from physics models combined with experimental data could dramatically decrease the amount of new data required.

It means that prior data are, in fact, not needed if you know enough about the physics that describes how an accelerator works. But that does not mean the data is not useful at all. During experiments, scientists used that data to further improve the physics-informed machine learning model by pairing it with actual data from the accelerator. The abovementioned experiment was performed on SLAC's SPEAR3 accelerator. Scientists used information obtained directly from physics-based models. They got results that were just as good, if not better, as those achieved by training the algorithm with actual archival data.



SLAC staff scientist Joe Duris, the study's principal investigator, said, "Our results are the latest highlight of a progressive push at SLAC to develop machine learning tools for tuning accelerators."

Scientists are now applying the method to improve the tuning of SLAC's Linac Coherent Light Source (LCLS) X-ray laser, one of the most powerful X-ray sources on the planet. Scientists noted, "The full potential of the new method will probably become apparent when SLAC crews turn on LCLS-II next year. This superconducting upgrade to LCLS has a brand-new accelerator, and its best settings need to be determined from scratch. Its operators may find it convenient to have AI by their side that has already learned some basics of accelerator physics." **—Agencies**