The Battle Against Illness in the Future

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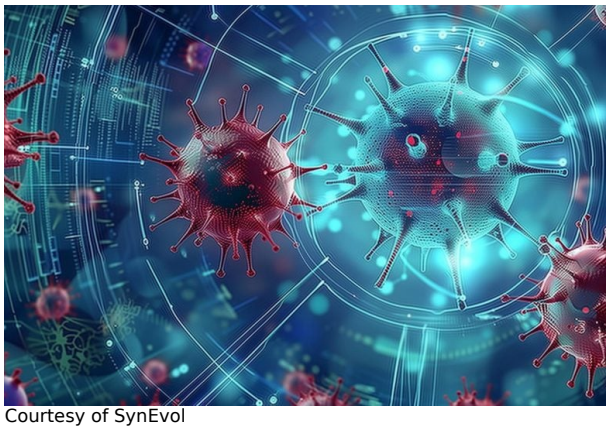
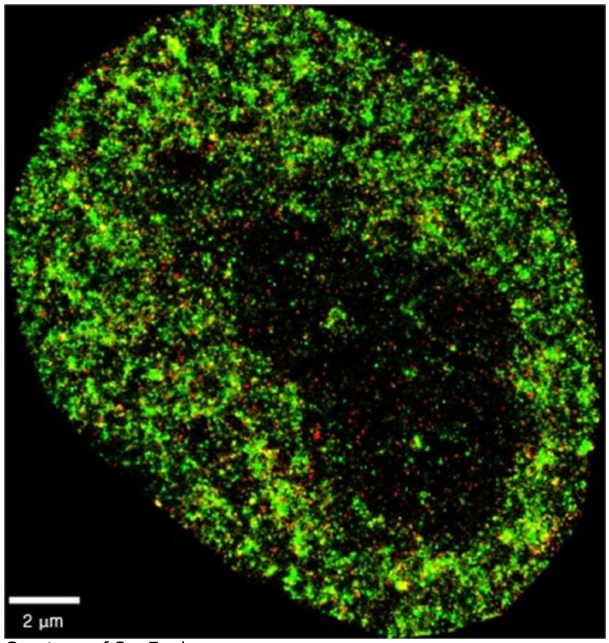


Courtesy of SynEvol

Researchers at the University of the Basque Country (UPV/EHU), the Fundación Biofisica Bizkaia (FBB, housed in the Biofisika Institute), the Donostia International Physics Center (DIPC), and the Centre for Genomic Regulation (CRG) have created an artificial intelligence that is able to distinguish between cancer and normal cells as well as identify the very early stages of viral infection inside cells. The results open the door to new approaches to disease monitoring and enhanced diagnostic methods.

AINU, or AI of the NUcleus, is a tool that analyzes high-resolution cell pictures. The photos are produced using a unique microscopy method known as STORM, which produces a picture that captures a great deal more fine information than is possible with conventional microscopes. The nanoscale resolution of the high-definition pictures reveals structures.

A human hair strand is around 100,000 nm wide, and a nanometer (nm) is one-billionth of a meter. Reorganizations within cells as small as 20 nm, or 5,000 times smaller than the width of a human hair, can be detected by the AI. These changes are too minute and nuanced for human observers to detect using conventional techniques alone.



Courtesy of SynEvol
Credit: Zhong Limei

"Our AI can identify distinct patterns and variations in these images with exceptional precision, such as modifications in the arrangement of DNA within cells, enabling the detection of changes in real time." We believe that in the future, this kind of data will allow medical professionals to better track illnesses, tailor their care, and enhance patient outcomes," says Pia Cosma, an ICREA Research Professor and researcher at the Centre for Genomic Regulation in Barcelona.

Convolutional neural networks, or AINUs, are specialized AI systems used to interpret visual input, such as photographs. Convolutional neural networks are utilized by self-driving cars to comprehend and navigate their surroundings by identifying things on the road, or by users to unlock cellphones using only their faces.

Convolutional neural networks are used in medicine to analyze pictures such as CT scans and mammograms and spot cancerous signals that the human eye could miss. Additionally, they can aid in the quicker and more precise diagnosis process by assisting medical professionals in identifying anomalies in MRI or X-ray scans.

AINU uses molecular analysis to find and examine microscopic features within cells. The model was trained by the researchers using nanoscale-resolution photographs of the nuclei of various cell types in various stages. By examining the distribution and arrangement of nuclear components in three dimensions, the model was trained to identify distinct patterns in cells.

For instance, as compared to normal cells, cancer cells exhibit unique modifications to their nuclear structure, such as changes to the arrangement of their DNA or the distribution of enzymes inside the nucleus. Following training, AINU was able to identify malignant or normal cell nuclei based only

on these characteristics when analyzing new images of the nuclei.

The AI was able to identify alterations in a cell's nucleus as soon as one hour after it was infected with the herpes simplex virus type-1 because to the photos' nanoscale resolution. When a virus begins to change the structure of the cell's nucleus, it causes small variations in the way DNA is packed, which the model may use to identify the virus's existence.

"Our approach can identify virus-infected cells relatively soon after the infection begins. Doctors typically need more time to diagnose infections because they rely on outward signs or more significant alterations in the body. Ignacio Arganda-Carreras, co-corresponding author of the study, Ikerbasque Research Associate at UPV/EHU, and linked with the FBB-Biofisika Institute and the DIPC in San Sebastián/Donostia, states, "But with AINU, we can see tiny changes in the cell's nucleus right away."

This technology allows researchers to observe how viruses impact cells practically instantly after entering the body, which may aid in the development of more effective therapies and vaccinations. AINU has the potential to expedite and improve the speed of infection diagnosis in hospitals and clinics by utilizing a basic tissue or blood sample, as stated by Limei Zhong, co-first author of the study and researcher at the Guangdong Provincial People's Hospital (GDPH) in Guangzhou, China.

Before the device is ready for testing or to be implemented in a clinical setting, the researchers need to overcome some significant obstacles. For instance, only specialist equipment often found in biological research labs may be used to take STORM photos. An enormous investment in technology and know-how is needed to set up and maintain the imaging systems that the AI requires.

The fact that STORM imaging normally only examines a small number of cells at once is another limitation. To diagnose or track a disease, physicians would need to capture many more cells in a single image for diagnostic reasons, particularly in clinical settings where time and efficiency are critical.

Rapid advancements in STORM imaging could soon lead to the availability of microscopes in less specialized or smaller facilities, and eventually even in clinical settings. We anticipate conducting preclinical trials shortly because the throughput and accessibility constraints are more manageable than we previously believed, according to Dr. Cosma.

Even though clinical advantages could not materialize for years, AINU is anticipated to hasten scientific research in the near future. The method, the researchers discovered, could detect stem cells with extremely high precision. Pluripotency is the ability of stem cells to grow into any form of cell in the body. The potential of pluripotent cells to aid in the replacement or repair of damaged tissues is being investigated.

By accelerating and improving the identification of pluripotent cells, AINU can contribute to the safety and efficacy of stem cell treatments. Animal testing is still used in current procedures to identify high-quality stem cells. But all our AI model requires to function is a sample that has been stained with particular markers that draw attention to important nuclear properties. According to Davide Carnevali, the study's first author and a researcher at the CRG, "it can expedite stem cell research while contributing to the shift in reducing animal use in science in addition to being easier and faster."