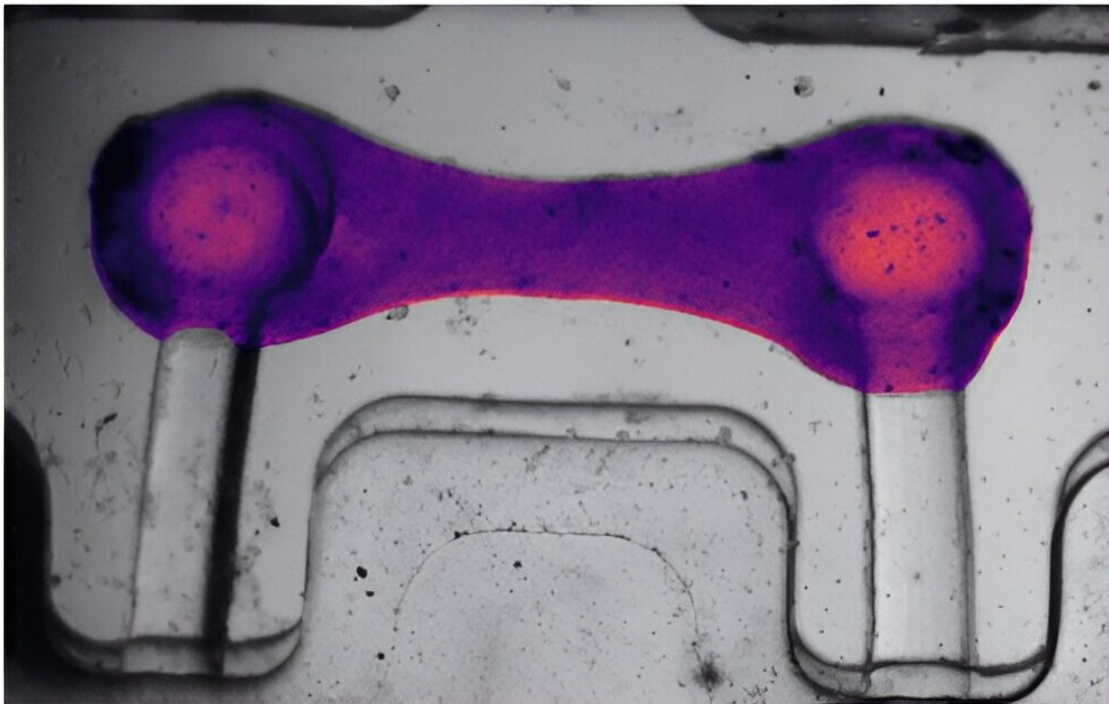# Biomedical engineers use AI to build new tool for studying and diagnosing heart function

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As seen through computer vision, BeatProfiler in action applied to cardiac tissue. Credit: Youngbin Kim/Columbia Engineering

Understanding heart function and disease, as well as testing new drugs for heart conditions, has long been a complex and time-consuming task.

A promising way to study disease and test new drugs is to use cellular and engineered tissue models in a dish, but existing methods to study heart cell contraction and calcium handling require a good deal of manual work, are prone to errors, and need expensive specialized equipment.

There clearly is a critical medical need for a more efficient, accurate, and accessible way to study heart function, using a methodology based on artificial intelligence (AI) and machine learning.

BeatProfiler, a new tool to rapidly analyze heart cell function

Researchers at Columbia Engineering have unveiled a new tool that addresses these challenges head-on. BeatProfiler is a comprehensive software that automates the analysis of heart cell function from video data and is the first system to integrate the analysis of different heart function indicators, such as contractility, calcium handling, and force output into one tool, speeding up the process significantly and reducing the chance for errors.

BeatProfiler enabled the researchers to not only distinguish between different diseases and levels of their severity but also to rapidly and objectively test drugs that affect heart function.

The study was published in the *IEEE Open Journal of Engineering in Medicine and Biology*.

"This is truly a transformative tool," said project leader Gordana Vunjak-Novakovic, University Professor and the Mikati Foundation Professor of Biomedical Engineering, Medical Sciences, and Dental Medicine at Columbia. "It's fast, comprehensive, automated, and compatible with a

broad range of computer platforms so it is easily accessible to investigators and clinicians."

Software is open-source

The team, which included Barry Fine, assistant professor of medicine (in Cardiology) at Columbia University Irving Medical Center, elected not to file a [patent application](link), and instead are offering the AI software as open-source, so it can be directly used—for free—by any lab.

They believe that this is important for disseminating the results of their research, as well as for getting feedback from users in academic, clinical, and commercial labs that can help the team to further refine the software.

The need to diagnose heart disease quickly and accurately

This project was driven, like much of Vunjak-Novakovic's research, by a clinical need to diagnose heart diseases more quickly and accurately. This was a project that was several years in the making, to which the team added different features piece by piece. While the overarching need was to develop a tool that could better capture the function of the cardiac models that the team was building to study cardiac diseases and assess the efficacy of potential therapeutics, the researchers had an urgent need to quickly and accurately assess the function of their cardiac models in real-time.

As the lab was making more and more cardiac tissues through innovations such as [milliPillar](link) and [multiorgan tissue models](link), the increased capabilities of the tissues required the researchers to develop a method to more rapidly quantify the function of cardiomyocytes (heart

muscle cells) and tissues to enable studies exploring genetic cardiomyopathies, cosmic radiation, immune-mediated inflammation, and drug discovery.

In the last year and a half, lead author Youngbin Kim and his co-authors developed a graphical user interface (GUI) on top of the code so that biomedical researchers with no coding expertise could easily analyze the data with just a few clicks.

This brought together experts in software development (for the GUI development), machine learning (for developing computer vision technology and disease/drug classifiers), signal processing (for processing contractile and calcium signals), engineering (translating pillar deflection on the cardiac platform to mechanical force), and user experience by lab members (to give feedback for improvements in the interface).

The results

The study showed that BeatProfiler could accurately analyze cardiomyocyte function, outperforming existing tools by being faster—up to 50 times in some cases—and more reliable. It detected subtle changes in engineered heat tissue force response that other tools might miss.

"This level of analysis speed and versatility is unprecedented in cardiac research," said Kim, a Ph.D. candidate in Vunjak-Novakovic's lab at Columbia Engineering. "Using machine learning, the functional measurements analyzed by BeatProfiler helped us to distinguish between diseased and healthy heart cells with high accuracy and even to classify different cardiac drugs based on how they affect the heart."

What's next

The team is working to expand BeatProfiler's capabilities for new applications in heart research, including a full spectrum of diseases that affect the pumping of the heart, and drug development. To ensure that BeatProfiler can be applied to a wide variety of research questions, they are testing and validating its performance across additional in vitro cardiac models, including different engineered heart tissue models.

They are also refining their machine-learning algorithm to extend and generalize its use to a variety of heart diseases and drug effect classification. The long-term goal is to adapt BeatProfiler to pharmaceutical settings to speed up the testing of hundreds of thousands of candidate drugs at once.

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