Expert Insights: AI-Powered Software Tools Enable Automated and Unbiased Live-Cell Health Analysis

August 2024 | Author: Tina Shahian, Scientific Content Writer, Sartorius

Introduction

Before modern tools, analyzing cell images was a manual task that took up hours of effort. Jasmine Trigg, a Scientist at Sartorius, remembers this well.

"Getting the insights I needed was challenging because accurately segmenting cells or analyzing them on a large scale were frequent pain points. Another difficulty was using imaging reagents, especially with neural cells, as they were sometimes incompatible with sensitive cells or introduced artifacts," she says from her days in a neuroscience lab.

Cell data form a critical pillar in advancing our collective knowledge of human health and finding effective treatments for diseases. Monitoring how cells grow and behave is central to this. While low-throughput or cell-destructive techniques have been immensely useful, more labs are adopting non-perturbing methodologies to monitor live cells in real time.

Image analysis techniques like noise reduction, segmentation, and feature extraction are common in such analysis. In manual workflows, these tasks require significant expertise and are prone to human error. For example, cell segmentation is a key step for identifying and separating different regions or objects within an image. Manual segmentation involves setting intensity thresholds to distinguish the foreground from the background and then using software to draw boundaries around cells or structures of interest with a computer mouse. As one can imagine, performing this task reproducibly and without bias on hundreds of thousands of cells is incredibly hard.

With artificial intelligence (AI) tools quickly becoming commonplace in laboratories, it is hard to imagine how we ever managed without them. For cell analysis, AI-enabled software, like the ones Trigg and her team are developing at Sartorius, has greatly automated workflows and removed subjectivity from the process.

AI-Powered Tools for Cell Analysis

The introduction of AI-driven tools has streamlined cell culture analysis by automating segmentation, feature extraction, and data analysis. This shift not only enhances accuracy and reproducibility but also allows researchers to focus on interpreting results rather than performing tedious manual tasks.

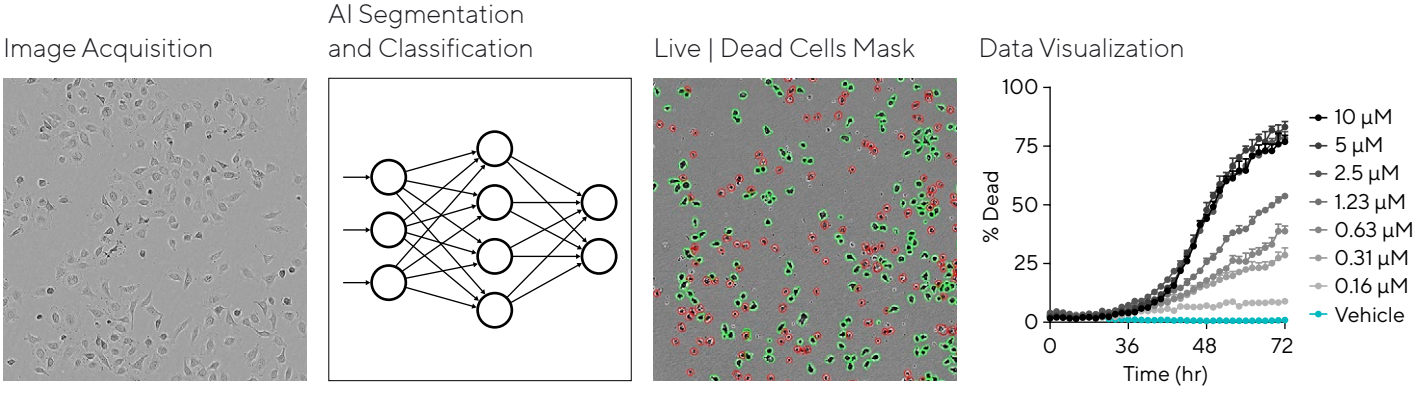
These tools utilize training data to develop models that can accurately analyze and classify cells in microscopy images. The training data consists of millions of high-quality images of cells that have been manually annotated to indicate features such as live versus dead cells or specific cell types.

Trigg is familiar with this process from developing new AI tools for automated analysis on the Incucyte® Live-Cell Analysis System.

"One thing you realize is how crucial it is to have high-quality ground truth data for training and validating the models. First, you need to be clear about what you want the model to do and the contexts in which it will be used. Second, it is important to be specific and consistent when annotating images for model training, and to include a wide range of examples. Finally, you must have good communication and understanding between software engineers and biologists to ensure the model works as intended."

The team applied this process to develop the Incucyte® AI Cell Health Analysis Software Module, one of the AI tools available for the Incucyte® system. With this tool scientists can accurately process and quantify live or dead cells without the need for fluorescent dyes, improving the biological relevance of their data (Figure 1).

Figure 1: *Incucyte® AI Cell Health Analysis Workflow.*



AI Cell Health Analysis Applications

Live | dead analysis is a key component of assessing overall cell health, essential for evaluating cell viability and understanding cellular responses to treatments or conditions.

The Incucyte® AI Cell Health Analysis Module automates this process by kinetically quantifying live and dead adherent and non-adherent cells over time, making it an invaluable tool in cell culture studies.

As Trigg explains, "AI tools provide unbiased cell analysis through a simple process, leading to better insights from both complex images and straightforward assays. They can accurately segment cells without interference from background elements like texture, scratches, or precipitation, and allow consistency across multiple conditions, significantly reducing time spent on analysis, especially at higher throughputs."

This module is widely utilized across several research fields, particularly those that require real-time monitoring and analysis of cell health.

Cancer Research
The module is used in cancer research for assessing drug cytotoxicity and evaluating the effects of various therapeutic compounds on tumor cells. Researchers leverage its capabilities to perform drug sensitivity assays, allowing for the quantification of live and dead cells without fluorescent labeling, which is crucial for studying primary cells and tumor cell lines.

Neuroscience
One of the unique challenges of working with neural cell types is their complex morphology and behavior, which makes manual analysis slow and error-prone. The Incucyte® AI Cell Health Analysis Module is essential for accurately segmenting these intricate morphologies to aid understanding glial cell health and the effects of different treatments.

Drug Development
AI-based image analysis is integral to high-throughput screening processes in drug development, allowing for efficient testing of compounds across multiple cell types and conditions. Its ability to provide real-time, label-free analysis enhances the throughput and reliability of drug testing protocols.

Conclusion

Machine learning techniques, such as convolutional neural networks, provide significant opportunities to streamline preprocessing and feature extraction, improving image quality and accuracy in routine cell analyses. Sartorius is leading the way with software solutions like the AI Cell Health Module and the AI Confluence Module. These tools enhance the precision and efficiency of live-cell analysis, enabling non-invasive, image-based measurements of cell growth and advancing our understanding of complex cellular processes.

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