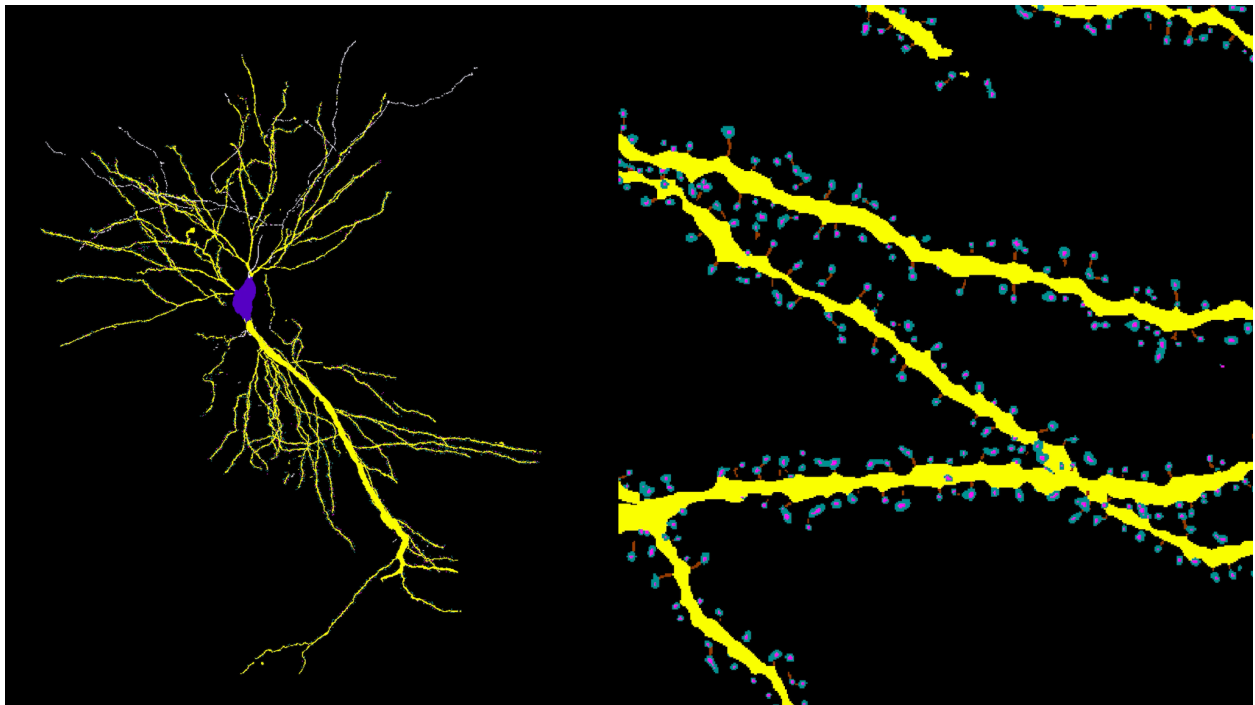


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AI Tool Reveals Complete 3D Architecture of Brain Cells

New open-source software could shed light on how brain diseases work



RESPAN maps thousands of excitatory synapses (spines) along the dendritic arbor (yellow) of a CA1 pyramidal neuron. (Credit: Kevin Gonzalez, Sergio Bernal-Garcia / Polleux lab / Zuckerman Institute and Luke Hammond / Ohio State University)

Monday, October 20, 2025

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NEW YORK – The neurons in our brain that underlie thought connect to each other using tiny branch-like structures on their surfaces known as dendritic spines. Now scientists at Columbia's Zuckerman Institute and their colleagues have come up with powerful new software driven by artificial intelligence that can automatically map these dendritic spines in pictures of neurons, a tool the researchers are making freely available.

"Dendritic spines are usually the first site that are implicated in neurodegenerative diseases such as Alzheimer's and Parkinson's," said [Sergio Bernal-Garcia](#), a graduate student in the lab of [Franck Polleux](#), PhD, and lead author of [the new study](#) detailing this work, published October 20 in *Cell Reports Methods*. "So understanding more about them is vitally important."

Dendritic spines are currently mostly counted manually. Painstaking analysis of hundreds of images of neurons can take weeks or months. With the new tool, named RESPAN (restoration enhanced spine and neuron analysis), "it just takes a couple of minutes on a computer," Bernal-Garcia said.

RESPAN can automatically identify a dendritic spine, measuring its volume, length and surface area. The software can display the spine's location on the cell and calculate the distance from the central part of the cell, and do so in live animals. It also provides multiple optional image restoration steps to help analyze especially challenging images, and ways for users to train their software on their unique datasets.

RESPAN not only outperformed manual analysis, it proved more accurate than previous neuron-analysis tools, detecting fewer false positives and negatives. "By using our freely available tool, researchers can greatly improve consistency and confidence in their results, helping to address the [reproducibility crisis](#) in biomedical science," said senior and corresponding author of the study Luke Hammond, former director of the Zuckerman Institute's Cellular Imaging platform and now director of Quantitative Imaging in the Neurology Department at The Ohio State University Wexner Medical Center.

The researchers sought to make RESPAN as user-friendly as possible. "Scientists **often** revert to manual approaches because the software packages that do exist for the task lack functionality or have limited accuracy when analyzing difficult images," Hammond said. "Importantly, users don't need to know any coding to use RESPAN, and we have a YouTube tutorial to guide users through each step."

With a new tool that can quickly and automatically map every dendritic spine on a neuron, the researchers hope they can make new discoveries. "By spatially mapping every spine on a neuron, we can now uncover whether certain locations are more susceptible to disease and begin asking whether spines in different areas have distinct molecular signatures," Bernal-Garcia said.

RESPAN can run on a PC or laptop with an NVIDIA GPU. The software is open-source, meaning that others are free to tinker with it as they please. "We encourage the community to adapt and improve RESPAN," Bernal-Garcia said.

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The [paper](#), “A deep learning pipeline for accurate and automated restoration, segmentation, and quantification of dendritic spines,” was published in *Cell Reports Methods* on October 20, 2025.

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The authors declare no competing interests.