

Reporting Summary

Nature Portfolio wishes to improve the reproducibility of the work that we publish. This form provides structure for consistency and transparency in reporting. For further information on Nature Portfolio policies, see our [Editorial Policies](#) and the [Editorial Policy Checklist](#).

Statistics

For all statistical analyses, confirm that the following items are present in the figure legend, table legend, main text, or Methods section.

n/a Confirmed

- | | | |
|-------------------------------------|-------------------------------------|--|
| ☐ | ☒ | The exact sample size (n) for each experimental group/condition, given as a discrete number and unit of measurement |
| ☐ | ☒ | A statement on whether measurements were taken from distinct samples or whether the same sample was measured repeatedly |
| ☐ | ☒ | The statistical test(s) used AND whether they are one- or two-sided
<i>Only common tests should be described solely by name; describe more complex techniques in the Methods section.</i> |
| ☒ | ☐ | A description of all covariates tested |
| ☒ | ☐ | A description of any assumptions or corrections, such as tests of normality and adjustment for multiple comparisons |
| ☐ | ☒ | A full description of the statistical parameters including central tendency (e.g. means) or other basic estimates (e.g. regression coefficient) AND variation (e.g. standard deviation) or associated estimates of uncertainty (e.g. confidence intervals) |
| ☐ | ☒ | For null hypothesis testing, the test statistic (e.g. F , t , r) with confidence intervals, effect sizes, degrees of freedom and P value noted
<i>Give P values as exact values whenever suitable.</i> |
| ☒ | ☐ | For Bayesian analysis, information on the choice of priors and Markov chain Monte Carlo settings |
| ☒ | ☐ | For hierarchical and complex designs, identification of the appropriate level for tests and full reporting of outcomes |
| ☒ | ☐ | Estimates of effect sizes (e.g. Cohen's d , Pearson's r), indicating how they were calculated |

Our web collection on [statistics for biologists](#) contains articles on many of the points above.

Software and code

Policy information about [availability of computer code](#)

Data collection

The evaluations of the proposed LargePNet method involve both open-source data and self-collected fluorescence microscopic images. The self-collected data used the following commercially available microscopes: a Leica SP8 3x STED microscope, an Aberrior STEDYCON STED microscope, an Airy Polar-SIM microscope, and an Airy NovSD microscope. The details are documented in the Methods section. All data used for network training are publicly available.

Data analysis

All data analysis is performed with home-written Python (version 3.10) and Matlab (2022b) codes.

For manuscripts utilizing custom algorithms or software that are central to the research but not yet described in published literature, software must be made available to editors and reviewers. We strongly encourage code deposition in a community repository (e.g. GitHub). See the Nature Portfolio [guidelines for submitting code & software](#) for further information.

Data

Policy information about [availability of data](#)

All manuscripts must include a [data availability statement](#). This statement should provide the following information, where applicable:

- Accession codes, unique identifiers, or web links for publicly available datasets
- A description of any restrictions on data availability
- For clinical datasets or third party data, please ensure that the statement adheres to our [policy](#)

The open-source data used in this study are all publicly available, as listed in Supplementary Table 10. The self-established dataset of STED denoising/deblurring, virtual sampling of SMLM, volumetric background removal datasets, and the source training data for the open-source BioSR and BioTISR datasets are available:

<https://zenodo.org/records/15694668>.

Research involving human participants, their data, or biological material

Policy information about studies with [human participants or human data](#). See also policy information about [sex, gender \(identity/presentation\), and sexual orientation](#) and [race, ethnicity and racism](#).

Reporting on sex and gender

Reporting on race, ethnicity, or other socially relevant groupings

Population characteristics

Recruitment

Ethics oversight

Note that full information on the approval of the study protocol must also be provided in the manuscript.

Field-specific reporting

Please select the one below that is the best fit for your research. If you are not sure, read the appropriate sections before making your selection.

☒ Life sciences ☐ Behavioural & social sciences ☐ Ecological, evolutionary & environmental sciences

For a reference copy of the document with all sections, see [nature.com/documents/nr-reporting-summary-flat.pdf](https://www.nature.com/documents/nr-reporting-summary-flat.pdf)

Life sciences study design

All studies must disclose on these points even when the disclosure is negative.

Sample size

Data exclusions

Replication

Randomization

Blinding

Reporting for specific materials, systems and methods

We require information from authors about some types of materials, experimental systems and methods used in many studies. Here, indicate whether each material, system or method listed is relevant to your study. If you are not sure if a list item applies to your research, read the appropriate section before selecting a response.

Materials & experimental systems

n/a Involved in the study

☐ ☒ Antibodies

☐ ☒ Eukaryotic cell lines

☒ ☐ Palaeontology and archaeology

☒ ☐ Animals and other organisms

☒ ☐ Clinical data

☒ ☐ Dual use research of concern

☒ ☐ Plants

Methods

n/a Involved in the study

☒ ☐ ChIP-seq

☒ ☐ Flow cytometry

☒ ☐ MRI-based neuroimaging

Antibodies

Antibodies used	Primary antibody: anti-alpha-tubulin antibody (Proteintech, 66031-1, 1:200), anti-GFP antibody (Millipore, G1546, 1:100); Secondary antibody: Secondary antibody used for DNA labeling (Jackson, 715-007-003), anti-mouse STAR Red (Abberior, STRED-1050-500UG, 1:200)
Validation	The anti-alpha-tubulin antibody (Proteintech, 66031-1) is a commercially available monoclonal antibody validated by the manufacturer for immunofluorescence (IF) applications in mammalian cells. The anti-GFP antibody (Millipore, G1546) has been validated for western blot (WB) and ELISA by the manufacturer. Secondary antibodies were used according to manufacturer recommendations.

Eukaryotic cell lines

Policy information about [cell lines and Sex and Gender in Research](#)

Cell line source(s)	Human osteosarcoma U2-OS cell line (HTB-96), human adenocarcinoma HeLa cell line (CRM-CCL-2), and cercopithecus aethiops COS-7 cell line (CRL-1651) were purchased from ATCC.
Authentication	We directly purchased the cell line from ATCC which has been authenticated.
Mycoplasma contamination	We confirm that the cell line we used was tested negative for mycoplasma contamination.
Commonly misidentified lines (See ICLAC register)	We don't use any commonly misidentified cell lines here.

Plants

Seed stocks	None
Novel plant genotypes	None
Authentication	None