

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 (<i>n</i>) 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. <i>F</i> , <i>t</i> , <i>r</i>) with confidence intervals, effect sizes, degrees of freedom and <i>P</i> 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 <i>d</i> , Pearson's <i>r</i>), 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	or data collection, we employed a custom-developed Graph Neural Network model, implemented using PyTorch. This model was utilized to simulate and process both synthetic and real network datasets for the purpose of our complex network compression study. All code and related datasets have been made publicly available on Github(https://github.com/3riccc/nfc_model)
Data analysis	Data analysis was conducted using the same Graph Neural Network models as mentioned above, implemented in PyTorch. We processed data through our custom algorithms to analyze the behavior and properties of network compression. The analysis code and data are accessible on our Github Repository(https://github.com/3riccc/nfc_model)

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](#)

All data used in this study, including synthetic datasets and real network datasets, have been made publicly available. The code and datasets have been uploaded to Github and can be accessed via the following link: https://github.com/3riccc/nfc_model. This study did not involve any third-party or clinical datasets, hence there are no additional restrictions on data access.

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	Not applicable as our study did not involve human participants or data derived from human subjects.
Reporting on race, ethnicity, or other socially relevant groupings	Not applicable as our study did not involve human participants or data derived from human subjects.
Population characteristics	Not applicable as our study did not involve human participants or data derived from human subjects.
Recruitment	Not applicable as our study did not involve human participants or data derived from human subjects.
Ethics oversight	No formal ethics approval was requested for this study as it did not involve any human participants, personal data, or biological materials.

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

Behavioural & social sciences study design

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

Study description	This is a quantitative computational study focused on the development and demonstration of a graph neural network model for network compression. The data used are quantitative and involve no primary data collection but utilize existing dataset for method validation.
Research sample	The research utilizes publicly available dataset: a scientist collaboration network. This dataset is used as a test cases to demonstrate the applicability of the proposed methodological approaches in complex network analysis. The datasets represent typical network structure in their respective fields.
Sampling strategy	Sampling strategy is not applicable as the study does not involve primary data collection. The datasets were selected based on their availability and relevance to the network types typical studies in complex systems analysis.
Data collection	Data collection involved retrieving data from public repositories. All analysis was conducted computationally. No physical data collection instruments were used as the study does not involve experimental manipulation or human subjects.
Timing	The datasets were accessed and analyzed during the period from Sep 2022 to Dec 2024. The computational experiments were performed in a continuous manner during this period.
Data exclusions	No data were excluded from the analyses. The entire dataset were utilized to ensure a comprehensive evaluation of the proposed network compression method.
Non-participation	Not applicable, as this study did not involve human participants.

Randomization

Not applicable, as this study did not involve the allocation of participants into experimental groups.

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

Plants

Seed stocks

Not applicable, as no plant materials or seed stocks were used in this study. Our research focus on computational analysis of network datasets.

Novel plant genotypes

Not applicable, as our study did not involve plant genotypes or any biological experiments.

Authentication

Not applicable, as our research did not involve any biological materials that required authentication.