nature portfolio

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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 *Only common tests should be described solely by name; describe more complex techniques in the Methods section.*
☐	☒	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 *Give P values as exact values whenever suitable.*
☐	☒	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	MIT-BIH arrhythmia database (v1.0.0), Modified National Institute of Standards and Technology database (MNIST database) (v3.0.1)
Data analysis	All the relevant codes are available from the corresponding author upon reasonable request.

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 the data supporting the findings of this study are available within the article and its Supplementary Information. The raw data generated in this study are available from the corresponding author upon request

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	This study is applicable to all sexes and genders. Sex and gender-based analyses were not performed. The purpose of this experiment was solely to collect data for hardware validation. No biometric data were stored, trained, or reused, and the study is entirely unrelated to any medical procedures. In selecting participants for the experiment, factors such as number of volunteers, sex, and age were not considered.
Reporting on race, ethnicity, or other socially relevant groupings	Information has not been collected.
Population characteristics	No covariate-relevant population characteristics have been collected. The purpose of this experiment was solely to collect data for hardware validation. No biometric data were stored, trained, or reused, and the study is entirely unrelated to any medical procedures. In selecting participants for the experiment, factors such as number of volunteers, sex, and age were not considered.
Recruitment	The participants volunteered. The purpose of this experiment was solely to collect data for hardware validation. No biometric data were stored, trained, or reused, and the study is entirely unrelated to any medical procedures. In selecting participants for the experiment, factors such as number of volunteers, sex, and age were not considered.
Ethics oversight	Korea Advanced Institute of Science & Technology Instituional Review Board (KAIST IRB)

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

Ecological, evolutionary & environmental sciences study design

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

Study description	Introducing a system for neural network applications using memristor with Pt/Ta2O5/NbOx/Al2O3/Ti structure. The sample showed long retention characteristics and high endurance characteristics suitable for applications.
Research sample	Samples made of conductor, insulator, and semiconductor materials.
Sampling strategy	Both the electrode patterns (including thickness and line width) and the sample size were chosen based on the device's electrical properties. In particular, the sample size was determined by the lithography equipment's limitations, which allowed for only the minimum achievable thickness.
Data collection	The first author measured the electrical characteristics of the device using probe station equipment.
Timing and spatial scale	The study began in March 2021, and finished in September 2024, and the fabricated devices were measured without a specific sampling period. The devices are 6-inch wafer size.
Data exclusions	No data were excluded.
Reproducibility	Contains endurance data from over 1e5 cycles of the device. I-V curves over 160 cells. Potentiation/depression over 70 repeated cycles.
Randomization	All samples were sampled without any specific rules and had the same electrical properties.
Blinding	Because it is an electronic device, blinding is impossible.

Did the study involve field work? ☐ Yes ☒ No

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	No plants involved in this study
Novel plant genotypes	No plants involved in this study
Authentication	No plants involved in this study