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	We created the dataset, which is available here: https://doi.org/10.6084/m9.figshare.19149779.v1
Data analysis	Sample codes supporting the results of this work are available here: https://github.com/lidongYang22/Autonomous-microrobot-swarm-navigation

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 dataset (~20 GB) used for training the DNNs are available in figshare: https://doi.org/10.6084/m9.figshare.19149779.v1.

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

Life sciences study design

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

Sample size	n/a
Data exclusions	n/a
Replication	n/a
Randomization	n/a
Blinding	n/a

Behavioural & social sciences study design

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

Study description	n/a
Research sample	n/a
Sampling strategy	n/a
Data collection	n/a
Timing	n/a
Data exclusions	n/a
Non-participation	n/a
Randomization	n/a

Ecological, evolutionary & environmental sciences study design

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

Study description	n/a
Research sample	n/a
Sampling strategy	n/a
Data collection	n/a
Timing and spatial scale	n/a
Data exclusions	n/a
Reproducibility	n/a
Randomization	n/a
Blinding	n/a

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
☐	☒ Human research participants
☒	☐ Clinical data
☒	☐ Dual use research of concern

Methods

n/a	Involved in the study
☒	☐ ChIP-seq
☒	☐ Flow cytometry
☒	☐ MRI-based neuroimaging

Human research participants

Policy information about studies involving human research participants

Population characteristics	Participants fulfill the following inclusion and exclusion criteria: Inclusion Criteria i. Healthy pregnant women at 20-45 years of age of any ethnic origin, giving childbirth with natural delivery or Caesarean sections after 37 - 42 weeks of gestation; ii. Singleton pregnancy; iii. Healthy as determined by laboratory results, physical exam and medical history; iv. Participant able to give voluntary, written, informed consent to participate in the study. Exclusion Criteria i. Abnormal prenatal development (e.g. intrauterine growth restriction); ii. Early preterm birth < 37 weeks; iii. Verbal confirmation of hypercholesterolemia ; iv. Family history of stroke or vascular disease; v. Type I or Type II diabetes and gestational diabetes; vi. Cancer, except skin cancers completely excised with no chemotherapy or radiation with a follow up that is negative; vii. Clinically significant abnormal laboratory results at screening; viii. Any other active or unstable medical condition; ix. History of liver disease; x. History of hypertension (including pre-clampsia).
Recruitment	Women fulfilling the inclusion and exclusion criteria (listed above) were recruited from the Department of Obstetrics and Gyanecology, Prince of Wales Hospital, Hong Kong. All potential subjects were given a detailed explanation and their permission was obtained before they were recruited into the study. A written consent form was signed by the participants. The participants can withdraw from the research without any repercussions.
Ethics oversight	The Joint Chinese University of Hong Kong-New Territories East Cluster Clinical Research Ethics Committee approved the study protocol (CREC Ref. No. 2020.384). Refer to the Supplementary Note 8 for details regarding ethics approval, recuitment, and consent.

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