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Last updated by author(s): Apr 2, 2025

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 used our self-developed software "EasyPathology" that is compatible with common eye trackers to collect gaze tracking data from pathologists. The public version of the software (V1.3, for reading data only) can be accessed from the link" https://github.com/MasyerN/PEAN "
Data analysis	The PEAN model code, will be made publicly available on open-source platforms. The code can be obtained through the following link: https://github.com/MasyerN/PEAN.

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 data involved in this study, including 1,565 skin WSIs along with their corresponding slide-reviewing data and manual annotations, will be made available for

access. The data generated in this study have been deposited in the Github database under accession code: https://github.com/MasyerN/PEAN . The aforementioned link provides access to 150 sets of readily available paired data. For access to additional datasets, interested parties are required to submit a formal request to the corresponding author, Professor Cui. There are no potential restrictions on the access of these additional data.

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 of gender or sex is not applicable to this study because our research subject is a deep learning model. Retrospective image data obtained from clinical institutions does not contain patient privacy (including gender). The recruited pathologists were responsible for reviewing images and providing diagnoses, serving as research participants rather than research subjects.
Reporting on race, ethnicity, or other socially relevant groupings	Reporting of race, ethnicity,or other socially relevant groupings is not applicable to this study because our research subject is a deep learning model. Retrospective image data obtained from clinical institutions does not contain patient privacy. We did not use any categorical variables related to social information. The recruited pathologists were responsible for reviewing images and providing diagnoses, serving as research participants rather than research subjects.
Population characteristics	See above
Recruitment	The pathologists who participated in the process of reviewing WSIs in the study were invited by the original research team. The pathologists possess requisite qualifications to conduct comprehensive evaluations of whole slide images. During their assessment of these images, these pathologists maintain their individual visual behavioral patterns, which inherently harbor biases. Such biases may potentially lead to a degradation in the performance of the trained artificial intelligence (AI) model. As reported in the manuscript, the inclusion of a greater number of pathologists (thus reducing bias) demonstrates a significant positive correlation with enhanced AI model performance. This potential limitation has been discussed in the manuscript, that is, the current study may not sufficient to cover the entire group of pathologists.
Ethics oversight	The dataset does not contain any personally identifiable information, and its release has been approved by the Medical Science Research Ethics Committee of the First Affiliated Hospital of China Medical University, with ethical code "kelunshen [2021] 2020-196-2" (number: AF-SOP-07-1.1-01).

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

Life sciences study design

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

Sample size	Nosample-size calculation was performed. We incorporated all available data from two clinical research centers spanning the period from 2016 to 2022.
Data exclusions	These WSIs were continuously collected during this time period to maintain a distribution similar to the real world. One WSI representing nevus and one WSI representing BCC are not included because their image quality is low. This involves re-examination by pathologists. The criteria for pathologists to judge data quality in this process are as follows: (1) tissue samples that were too small or had diagnostic areas too limited to adequately represent the entirety of the disease; (2) folded sections; (3) overstaining; (4) high levels of tissue fragmentation; and (5) a significant presence of bubbles. When pathologists believe that the occurrence of the above situations interference making a diagnosis, the corresponding WSI will be excluded. Since this process is relatively subjective, two pathologists participated in the screening. Only when they unanimously recognize the image quality will the WSI be included in the data set.
Replication	We confirm that all reported structures can be replicated using publicly available code.
Randomization	5,881 WSIs covering 5 categories of skin lesions were collected from two medical research institutions. We collected slide review data and manual pixel annotations for approximately 25% of the WSIs and used these as the training set. Two testing sets were constituted from the remaining WSIs: an internal testing set (2,431) sourced from the same institution as the training data, and an external testing set (1,982) sourced from the other institution. The manual pixelwise annotation was only used for training comparative algorithms and was not involved in the development of our model.
Blinding	Researchers have no control over data allocation, which depends entirely on a random process.

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	This study does not involve plants. We have marked "n/a" in the table above, which may be a bug.
Novel plant genotypes	See above.
Authentication	See above.