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Australia's National Science Agency

A deep learning-based system for assessment of dental caries using colour dental photographs

Maryam Mehdizadeh | 9th July 2023

Maryam MEHDIZADEH a,1, Mohamed ESTAI a,b, Janardhan VIGNARAJAN a
Jilen PATEL c, d, Joanna GRANICH e, Michael ZANINOVICH f, Estie KRUGER b
John WINTERS d, Marc TENNANTS b and Sajib SAHA a

a Australian e-Health Research Centre

b & c School of Human Science & UWA Dental School

d Department of Pediatric Dentistry

e Telethon Kids Institute

f Aria Dental

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Outline

- Introduction to the problem
- Aims of this study
- Data collection
  - Image types
  - ICDAS-system annotation and sample image
  - Data representation
- System development
  - Training CNN networks
  - Regions of Interest (ROIs)
- Experimental Analysis
  - Evaluation Metrics
  - Results
- Discussion

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Introduction to problem

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Dental Caries in childhood

- Common chronic disease
- Effects half of population globally
- Temporary shutdown of dental services
- Ongoing challenge in remote and rural areas
- Overburden the health systems

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Aims of the study

Aims

- Develop and validate an automated system
- Low cost
- Using colour dental photos (smart phone photos)

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Data collection

Data collection

- 1020 child dental photos (up to 15 years of age)
  - Existing records of UWA dental school
  - Private dental practice in Perth, Australia (2021)
- Images were reviewed and annotated by calibrated dental reviewers
- Ethical approval was obtained from Human Research Ethics committees (@CSIRO)
- This work was funded by Western Australia Future Health Research and Innovation (FHRI) fund.

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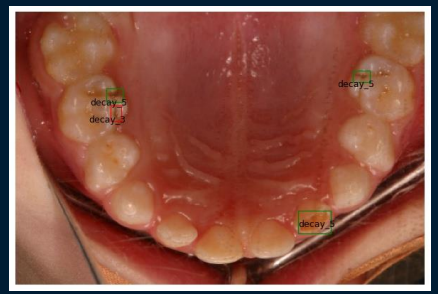
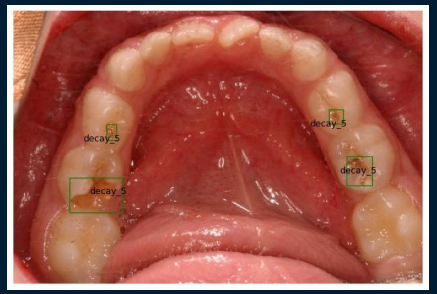
Image types

- Images were obtained in different views
  - Frontal
  - Upper occlusal
  - Lower occlusal
- Anonymous
- JPG format





ICDAS-annotation

- International Caries Detection and Assessment System
- Consistent and reliable for evaluating lesions across population, clinical settings, and research results
- Numerical code from 0 to 6, 0 indicating no carries, 6 indicating extensive cavitation
- ICDAS-3 was chosen as cut-off point in our study

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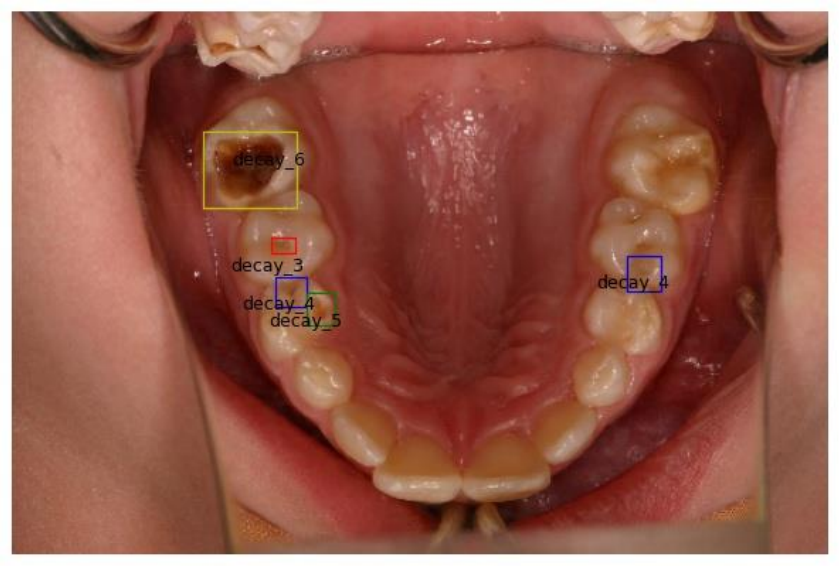
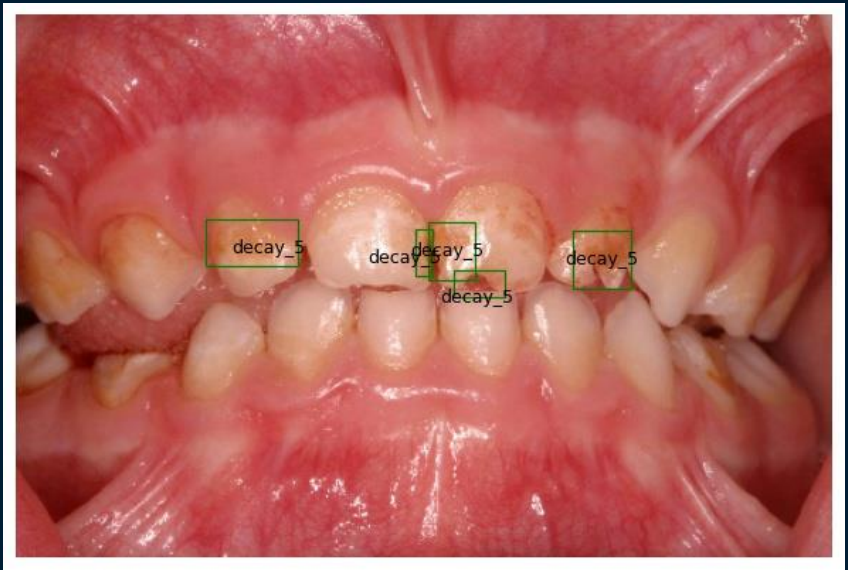
ICDAS-annotations sample





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Data representation

- 359 images were carries free
- 661 had dental carries (588 had ICDAS $\geq$ 3)
- Eliminated 144 images with frontal view
- 242 lesions ICDAS-3
- 297 lesions ICDAS-4
- 1082 lesions ICDAS-5
- 280 lesions ICDAS-6

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System development

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Training of CNN networks

- Three widely used classification networks
  - VGG-16
  - ResNet-50
  - Inception-v3
- Classification of ‘Carries’ vs ‘Sound’
- 10-fold cross-validation (average of the 10-training performance)

Regions of Interest (ROI)

- 13,684 ROI – 6952 ‘carries’ and 6732 ‘sound’
- Image augmentation
  - Rotation 15°
  - Height and width shift (0.2 range)
  - Horizontal and vertical flip

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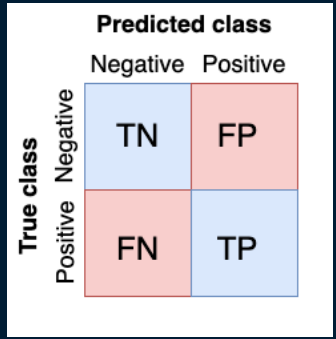
Experimental analysis

Evaluation metrics

- Considering a binary classification problem:
  - true negative (TN), false positive (FP), false negative (FN), true positive (TP)
- $Accuracy = \frac{TN+TP}{TN+FP+TP+FN}$
- $Precision(positive\ predicted\ value) = \frac{TP}{TP+FP}$
- $Recall(sensitivity) = \frac{TP}{TP+FN}$
- $Specificity = \frac{TN}{FP+TN}$
- $F1\ score = 2 \times \frac{Precision \times Recall}{Precision + Recall}$



Results

Performance criteria	VGG-16 (95% CI)	ResNet-50 (95% CI)	Inception-v3 (95% CI)
Recall	0.87(0.81-0.93)	0.50(0.5-0.5)	0.75(0.70-0.80)
Precision	0.82 (0.76–0.88)	1.0 (1.0–1.0)	0.95 (0.93–0.97)
Specificity	0.81 (0.75–0.88)	1.0 (1.0–1.0)	0.94 (0.91–0.97)
Accuracy	0.72 (0.66–0.78)	0.47 (0.45–0.50)	0.79 (0.75–0.82)
F1 Score	0.79 (0.67–0.83)	0.66 (0.66–0.66)	0.83 (0.80–0.85)

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Discussion

Discussion

- Best performing network was Inception-v3
- The system could be a viable tool in early detection and assessment of dental carries in childhood using colour dental photographs
- Further research is needed to evaluate these models on larger datasets to determine their generalizability and clinical utility
- Continued investigation could have significant implications for future use of deep learning in dental imaging

Thank you

Health & Biosecurity
Maryam Mehdizadeh
Software Engineer

maryam.mehdizadeh@csiro.au

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