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Source:	Charité Universitätsmedizin Berlin				
Title:	Att.6 – Presentation - Overcoming Current Challenges in Dental Deep Learning				
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Abstract:	This PPT contains a presentation on overcoming current challenges in dental deep learning given in the AI for Dentistry Symposium on 21 March 2023.				



Oral Diagnostics, Digital Dentistry and Health Services Research

Overcoming Current Challenges in Dental Deep Learning

Martha Büttner | 21.03.2023 | Dental Symposium WHO & ITU FG AI4H

Agenda - Challenges

- 1. Data sharing
- 2. Annotation bottle neck
- 3. Missing comparability



Data Sharing



Challenge International Data Sharing

- AI requires big amount of data
- Medical data is high sensitive
- Especially dental image data difficult to de-identify
- Data protection barriers are high
- Generalizabilty of deep learning models of high importance
- AI model performance differ when exposed to data from different centers
- Leeds to bias and unfair medical diagnostic

Proposed Solution

Federated Learning



Project

Federated Learning for Tooth Segmentation

- Simulation of FL on data from 9 different centers
- Tooth segmentation on panoramic images (n=143 to n=1,881 per center)
- Compared against local learning
- 8 out of 9 centers: FL outperformed local learning
- FL outperformed local learning across all centers in generalizability



Annotation Bottle Neck



- Most medical AI solution trained in a supervised manner
- High amount of labeled data required
- Expert needed for annotation
- Time consuming
- Cost intensive

Proposed Solution

Semi Supervised Learning

• First Model trained on small amount of labeled data

 \rightarrow Teacher model

- Prediction on unlabeled data
- Prediction used to train a new model
 - \rightarrow Student model
- Fine tuning on labeled data
- Student model becomes a teacher model

Project

Semi supervised caries segmentation

- Application of semi-supervised learning to two diffrent problems and data types
- Angle classification on intraoral photographs
- Segmentation of caries lesions on bitewing radiographs
- Model benefited from semi supervised approach
- Student model outperformed teacher models significantly (evaluated metrics: Dice, IoU, Sensitivity, PPV)



Missing Comparability

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Challenge Missing Comparability

- Inconsistent reporting
- Systematic review identified high amount of different metrics
- Difficult to perform meta analysis

	Classification task	Object detection	Semantic segmentation task	Instance segmentation task	Generation task
		task			
Number of studies	85	22	37	19	5
Performance metrics					
Accuracy	65	9	12	17	
Intersection over union or DICE indices or Jaccard		4	26	0	2
similarity coefficient		4	20	9	Z
Sensitivity or recall or true positve rate	55	19	22	11	
Precision or positive predictive value	30	12	15	7	
Mean average precision		2			
Area under the receiver-operating curve	36	3	4		
F indices	16	7	6	4	
Specificity or true negative rate	34	4	8	4	
Negative predictive value	8		3	1	
Rank-N recognition rate	1				
Mean or normalized absolute difference	3	2	2	3	1
Relative error or mean error rate or root mean squared	0	0			2
error	8	2	4	4	3
Correlation coefficients (Intra-class or Matthew's or	10	1			
Pearson's correlation coefficient or Cohen's kappa)	10	1	4	4	
Confusion matrices	8	3	2	1	
Time taken for analysis	6	1	1	4	2
Co-efficient of variation		1	2		1 A A
Failure rate	2	1			
Intra-CNN, inter-CNN consistency values	1		1		
Area under the precision recall curve	3				
Youden index	1				
False positive rate	2	1	2		
Difference between volumes or surfaces or points					
(Hausdorff distance, Relative volume difference, Average			6	3	1
symmetric surface distance, Mean curve distance)					
Incremental cost-effectiveness ratio			1		
Structural similarity			3		3
Sum of square difference			1		
Peak signal-to-noise ratio					3

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- Inconsistent reporting
- Systematic review identified high amount of different metrics
- Difficult to perform meta analysis
- Current reporting guidelines do not focus on metrics
- Metrics need technical knowledge to interpret
- Medical devices need evaluation on clinical metrics based on confusion matrix

Outlook

Core Outcome Development

- Development of reporting guidelines for dental computer vision
- Combining clinical and technical perspective
- Translation to clinical interpretable metrics
- 1. Consensus for reporting requirement
- 2. Manuals for generating clinical relevant metrics



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Thank you for your attention!

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