FGAI4H-R-040-A12

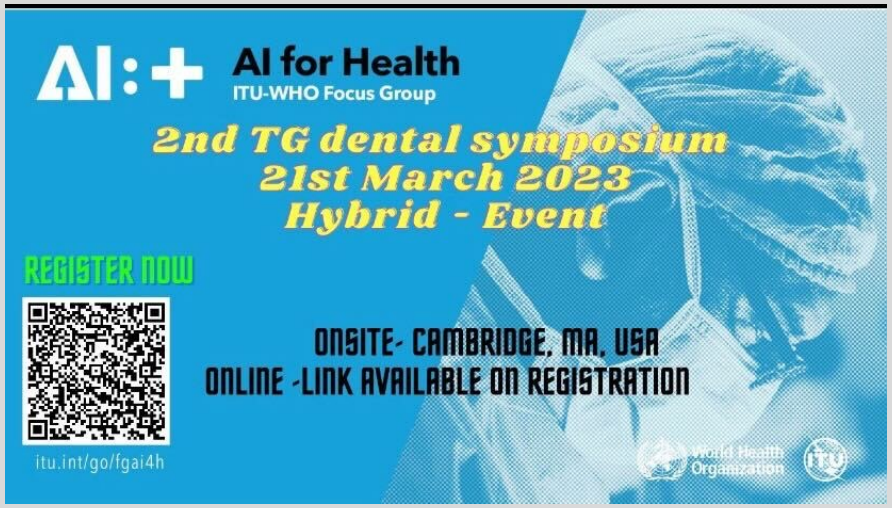
Cambridge, 21-24 March 2023

Source:	Nielsen Santos Pereira
Title:	Att.12 – Presentation - How to determine the sample-size for machine learning in dental imaging

Contact:	Nielsen Santos Pereira	E-mail: nielsen.spereira@gmail.com

Abstract:	This PPT contains a presentation on how to determine the sample-size for machine learning in dental imaging given in the AI for Dentistry Symposium on 21 March 2023.

Meeting R - TG-Dental



March 21-24 - 2023

Falk Schwendicke, Joachim Krois, Tarry Singh,
Jae-Hong Lee, Akhilanand Chaurasia, Robert André Gaudin, Sergio Uribe, Hossein Mohammad-Rahimi, Janet Brinz, Anahita Haiat, Gürkan Ünsal, **Nielsen Santos Pereira**, Ulrike Kuchler, Shankeeth Vinayahalingam, Balazs Feher, Francesc Perez Pastor, Lisa Schneider, Chen Nadler, Sahel Hassanzadeh-Samani, Parisa Motie, Ragda Abdalla-Aslan, Teodora Karteva, Jelena Roganovic, Kunaal Dhingra, Prabhat Kumar Chaudhari, Olga Tryfonos, Marja Laine, Rata Rokhshad, Fatemeh Sohrabniya, Zeynab Pirayesh, Shada Alsalamah, Sakher AlQahtani, Revan Birke Koca-Ünsal, Lubaina T. Arsiwala, Parul Khare, Amit Punj, Manal Hamdan, Zaid Badr, Tamara Peric, Mihiri Silva, Bree Jones, Miroslav Radenković, Martha Duchrau, Mohammed Omar, Gowri Sivaramakrishnan, Jaisri Thoppay, Saujanya Karki, Tarja Tanner, Marja-Liisa Laitala, Johannes Tanne

Question

AI for Health
ITU-WHO Focus Group

How to determine the sample-size for machine learning in dental imaging?

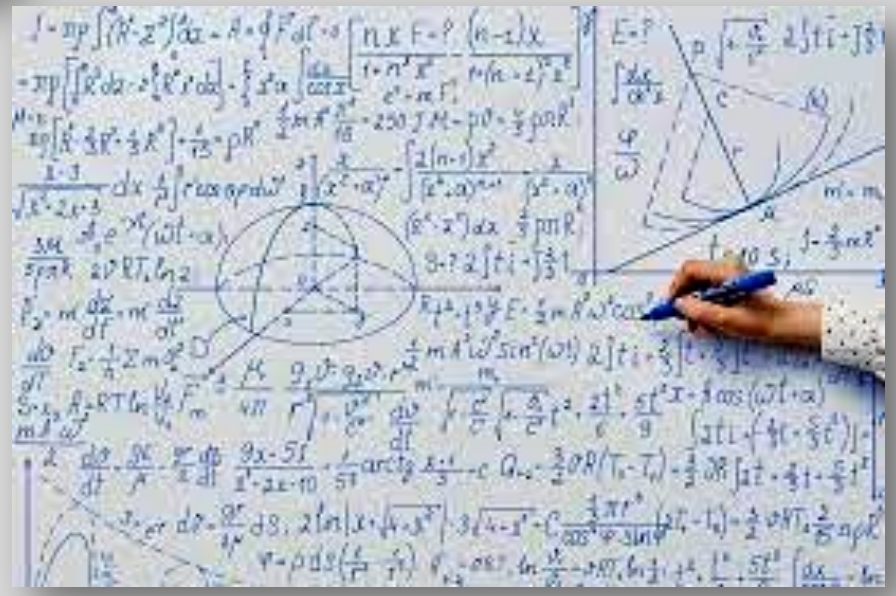
Dr. Nielsen S. Pereira – nielsen.spereira@gmail.com

Answers

AI for Health
ITU-WHO Focus Group

Answers

AI for Health
ITU-WHO Focus Group



Answers

AI for Health
ITU-WHO Focus Group

In Theory: Definition

AI for Health
ITU-WHO Focus Group

"In classical statistics, Sample-Size Determination Methodologies (SSDMs) estimate the optimum number of participants to arrive at scientifically valid results, often balancing an acceptable degree of precision with availability of resources"

Sample-Size Determination Methodologies for Machine Learning in Medical Imaging Research: A Systematic Review
•September 2019
•Canadian Association of Radiologists Journal 70(4)
DOI:10.1016/j.carj.2019.06.002

In Theory: in Medicine/Dentistry

AI for Health
ITU-WHO Focus Group

"Analogously, for ML in medical imaging, we define an SSDM as a procedure to estimate the number of images required for an ML algorithm to reach a particular threshold of performance, or a sufficiently low generalizability error. While sample size issues may affect many ML disciplines, this is a particularly poignant challenge in medical imaging, where access to large quantities of high quality data is elusive"

Sample-Size Determination Methodologies for Machine Learning in Medical Imaging Research: A Systematic Review
•September 2019
•Canadian Association of Radiologists Journal 70(4)
DOI:10.1016/j.carj.2019.06.002

In Theory: Approaches

AI for Health
ITU-WHO Focus Group

	Pre Hoc SSDMs	*Post Hoc* SSDMs
Efficiency	Fast, not computationally demanding	Computationally Demanding (require Performance Testing Procedures - *PTPs*)
Machine Learning (ML) Task	Validated for simpler binary classification tasks	Validated for multiclass classification problems
Dimensionality/Imaging Modality	Generally for low dimensional data	Validated for higher dimensional data
Algorithm	Validated for simple ML algorithms and single hidden layer feed forward neural networks	Validated for more complex algorithms and convolutional neural networks
Complexity of Problem	Ideal for relatively simpler tasks (e.g. high inter-class differences, distributional assumptions to data structure)	May be more ideal for complex ML tasks (subtler inter-class differences, need for higher generalizability)
Validity of Sample Size Estimate	Can vary greatly based on methods used and the ML tasks.	Error between estimated performance and actual performance can <5%. *NxSubsampling* and *Nx Cross Validation PTPs* may have higher variance of performance estimate at low subsample sizes and low test sizes respectively.

Sample-Size Determination Methodologies for Machine Learning in Medical Imaging Research: A Systematic Review
•September 2019
•Canadian Association of Radiologists Journal 70(4)
DOI:10.1016/j.carj.2019.06.002

In Practice

AI for Health
ITU-WHO Focus Group

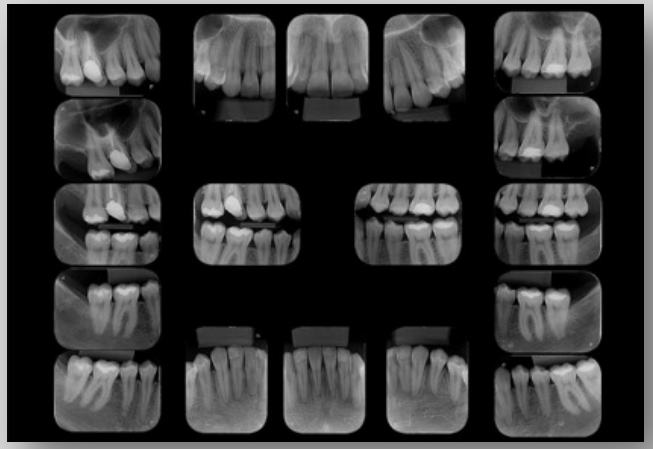
- The Goal of your Project
- The Task you are planning to
- The Architecture or Network
- The Availability of Data
- Previous researches or papers
- The Annotation Process
- The Infrastructure
- The Modality

The Modalities

AI for Health
ITU-WHO Focus Group

The Modalities

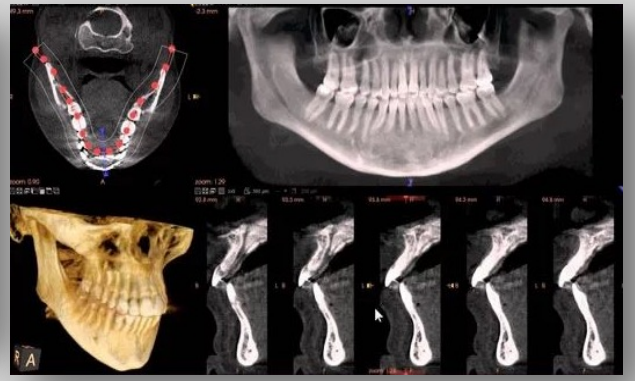
AI for Health
ITU-WHO Focus Group

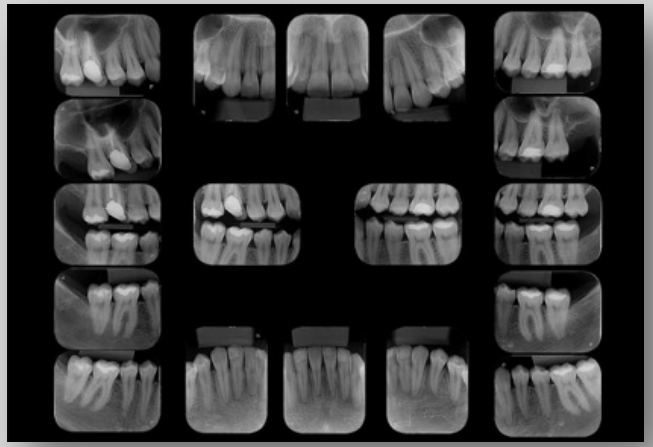


Dr. Nielsen S. Pereira – nielsen.spereira@gmail.com

The Modalities

AI for Health
ITU-WHO Focus Group

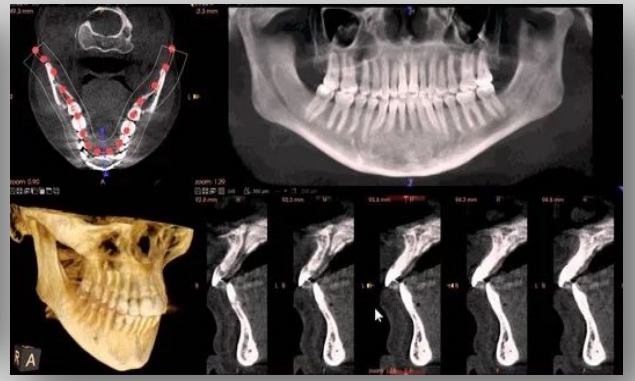


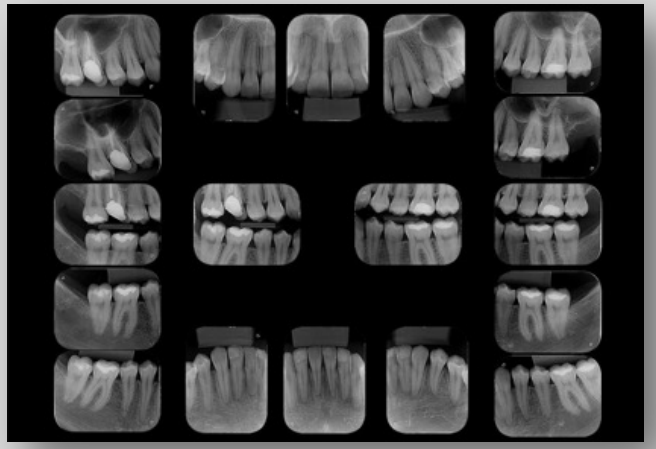


Dr. Nielsen S. Pereira – nielsen.spereira@gmail.com

The Modalities

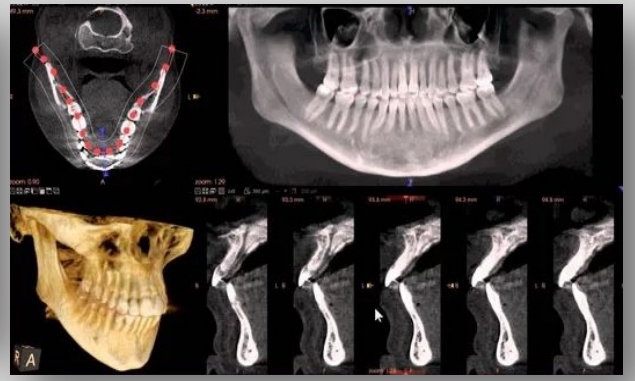
AI for Health
ITU-WHO Focus Group

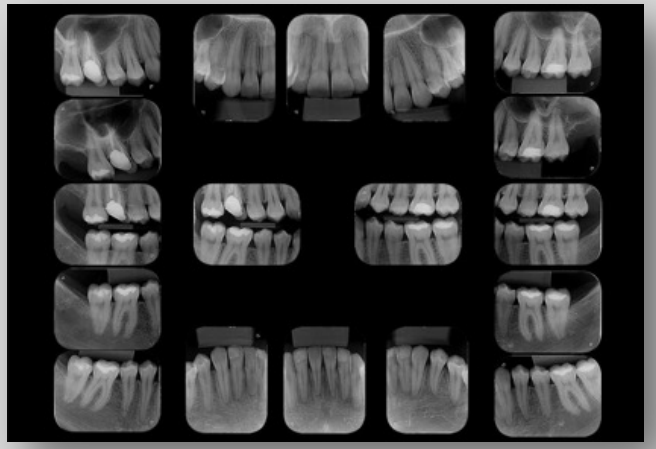




The Modalities

AI for Health
ITU-WHO Focus Group

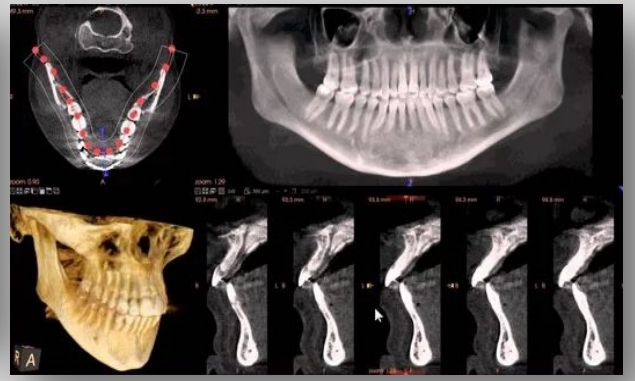


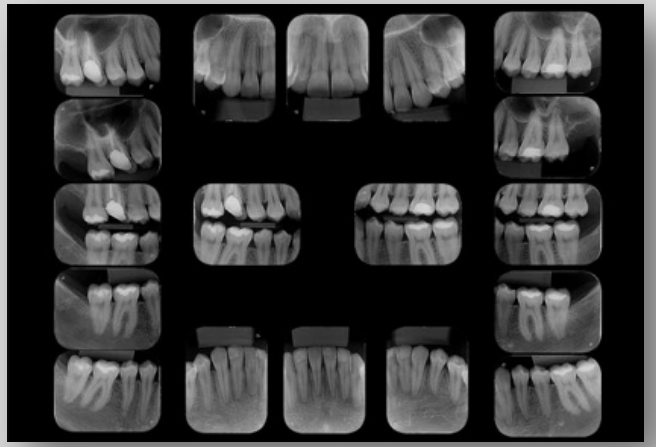


Dr. Nielsen S. Pereira – nielsen.spereira@gmail.com

The Modalities

AI for Health
ITU-WHO Focus Group





The Modalities Comparison

AI for Health
ITU-WHO Focus Group

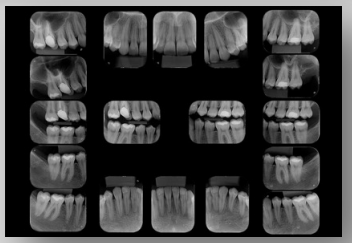
Panoramic or OPG – 1.000

Dr. Nielsen S. Pereira – nielsen.spereira@gmail.com

The Modalities Comparison

AI for Health
ITU-WHO Focus Group

Panoramic or OPG – 1.000



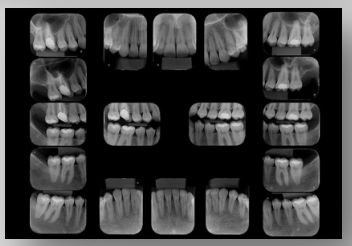
Periapical or Intraoral – 18.000

Dr. Nielsen S. Pereira – nielsen.spereira@gmail.com

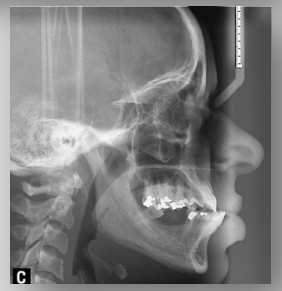
The Modalities Comparison

AI for Health
ITU-WHO Focus Group

Panoramic or OPG – 1.000



Periapical or Intraoral – 18.000



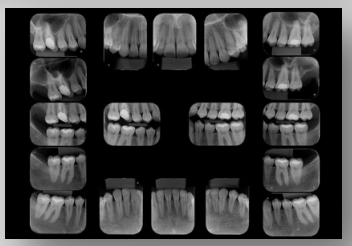
Lateral Cephalometric – 1.000

Dr. Nielsen S. Pereira – nielsen.spereira@gmail.com

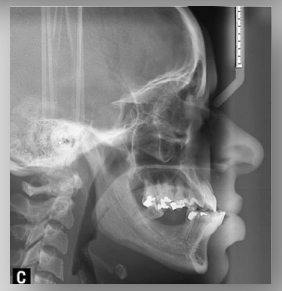
The Modalities Comparison

AI for Health
ITU-WHO Focus Group

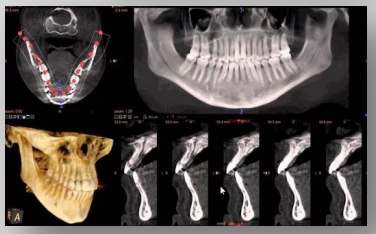
Panoramic or OPG – 1.000



Periapical or Intraoral – 18.000



Lateral Cephalometric – 1.000

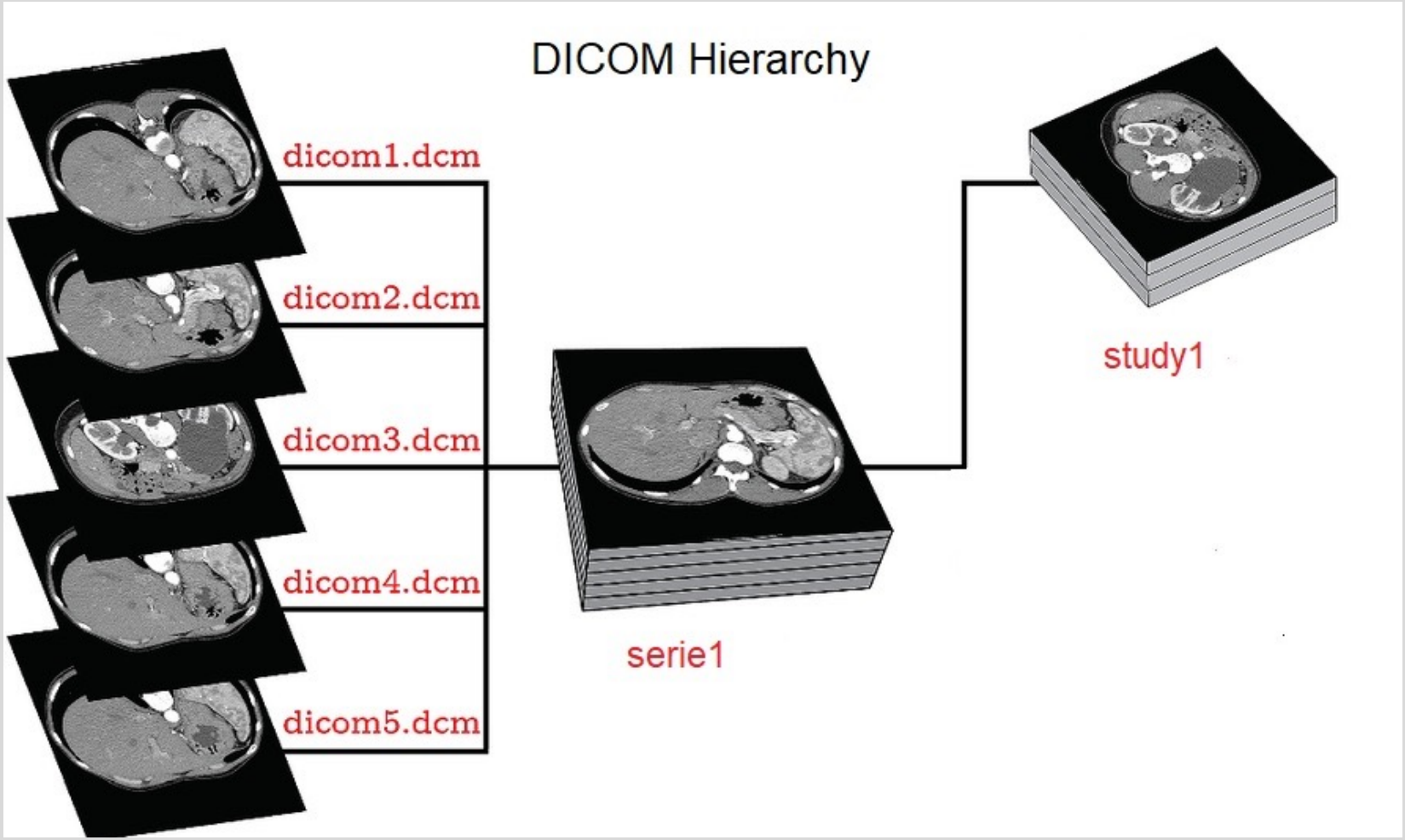


CBCT – 180.000

Dr. Nielsen S. Pereira – nielsen.spereira@gmail.com

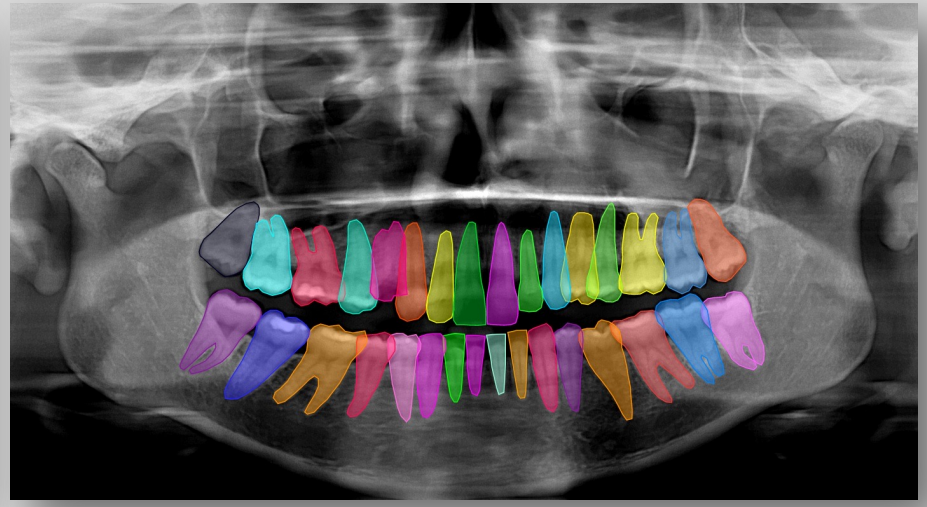
The DICOM Hierarchy

AI for Health
ITU-WHO Focus Group



Quantity x Quality

AI for Health
ITU-WHO Focus Group



MODEL

Dr. Nielsen S. Pereira – nielsen.spereira@gmail.com

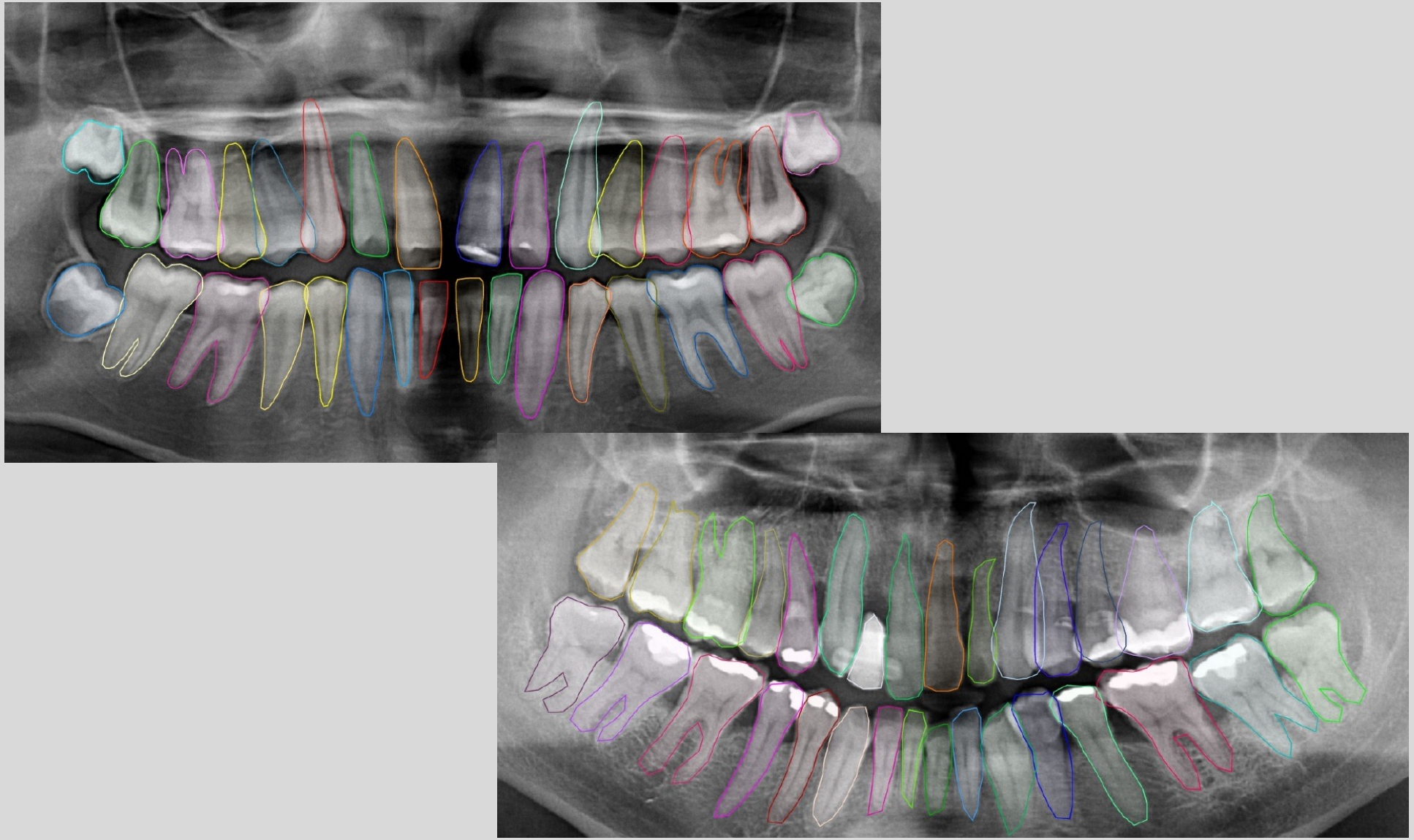
Annotation Task

AI for Health
ITU-WHO Focus Group

1. The Annotation Tool
2. Experienced and Certified Team
3. OMFR Supervisor
4. Annotation Guideline
5. Calibration Meeting
6. Calibration Dataset
7. Team annotation follow up and corrections
8. Specify a Deadline

Annotation Task

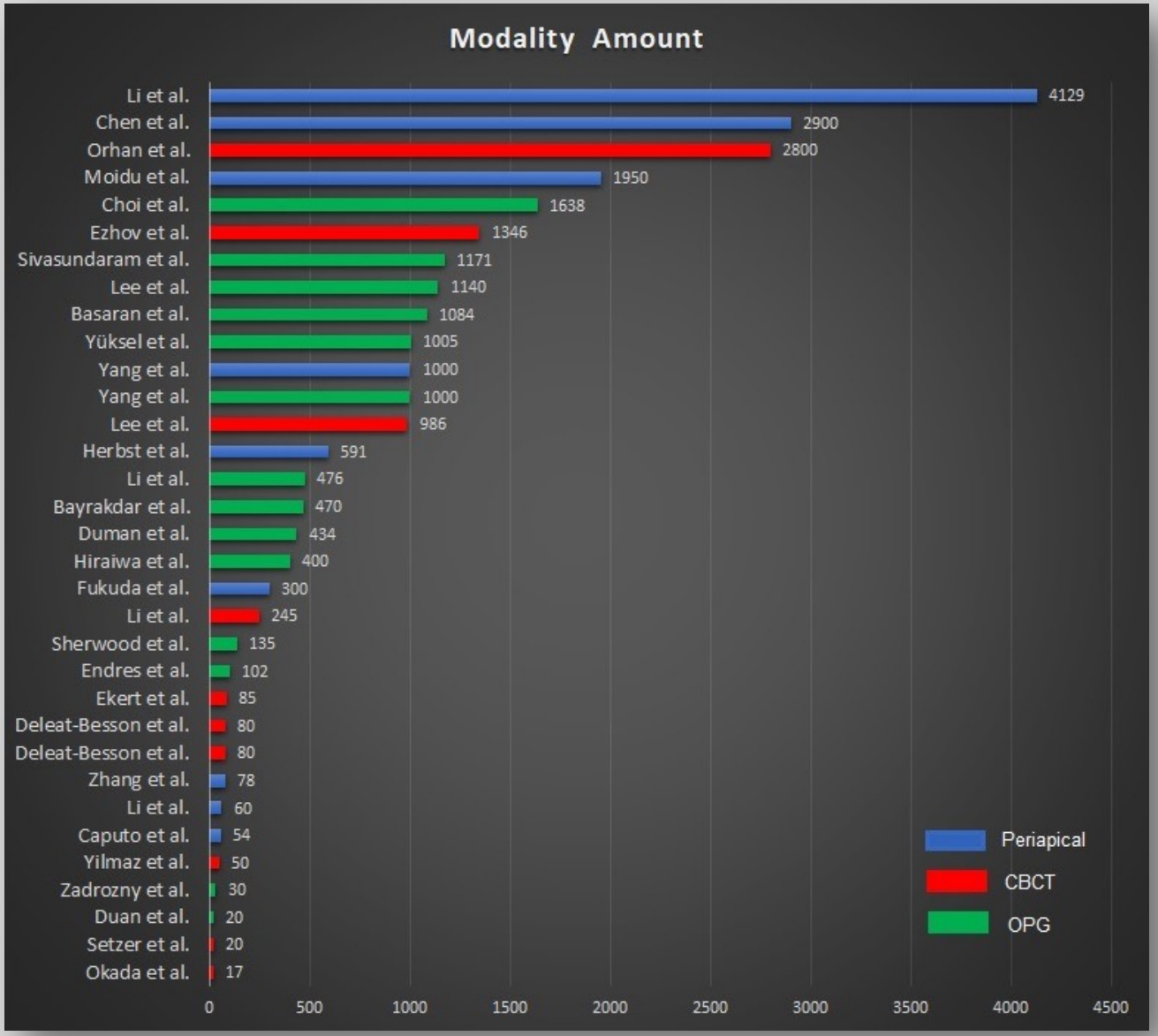
AI for Health
ITU-WHO Focus Group



Dr. Nielsen S. Pereira – nielsen.spereira@gmail.com

Example

AI for Health
ITU-WHO Focus Group



Open Dataset Risk

AI for Health
ITU-WHO Focus Group

1. The Raw Data
2. Metadata (Gender, Sex, Equipment, etc.)
3. The ORIGIN of the data
4. Selection Criteria (Randomization / Anonymization
5. If annotated, the quality of the annotation

Open Dataset Risk

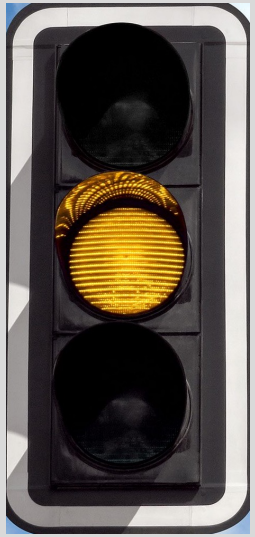
AI for Health
ITU-WHO Focus Group

1. The Raw Data
2. Metadata (Gender, Sex, Equipment, etc.)
3. The ORIGIN of the data
4. Selection Criteria (Randomization / Anonymization
5. If annotated, the quality of the annotation

Open Dataset Risk

AI for Health
ITU-WHO Focus Group

1. The Raw Data
2. Metadata (Gender, Sex, Equipment, etc.)
3. The ORIGIN of the data
4. Selection Criteria (Randomization / Anonymization
5. If annotated, the quality of the annotation



Open Dataset Risk

AI for Health
ITU-WHO Focus Group

1. The Raw Data
2. Metadata (Gender, Sex, Equipment, etc.)
3. The ORIGIN of the data
4. Selection Criteria (Randomization / Anonymization
5. If annotated, the quality of the annotation

AI for Health
ITU-WHO Focus Group

Thank you very much!

Dr. Nielsen S. Pereira
nielsen.spereira@gmail.com