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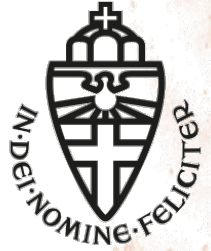
UNIVERSITÀ DEGLI STUDI DI  
MODENA E REGGIO EMILIA

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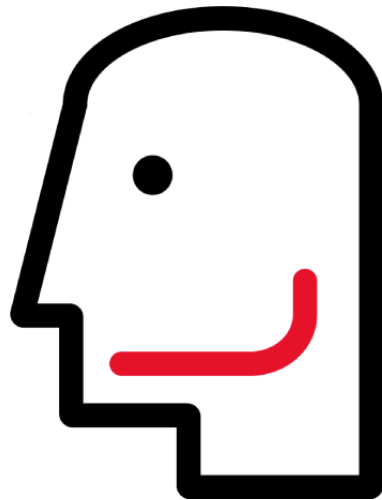


SCAN ME

**MICCAI**2024   
*Marrakesh*  
MOROCCO



**Radboud  
Universiteit**



**TOOTH  
FAIRY2**



SCAN ME

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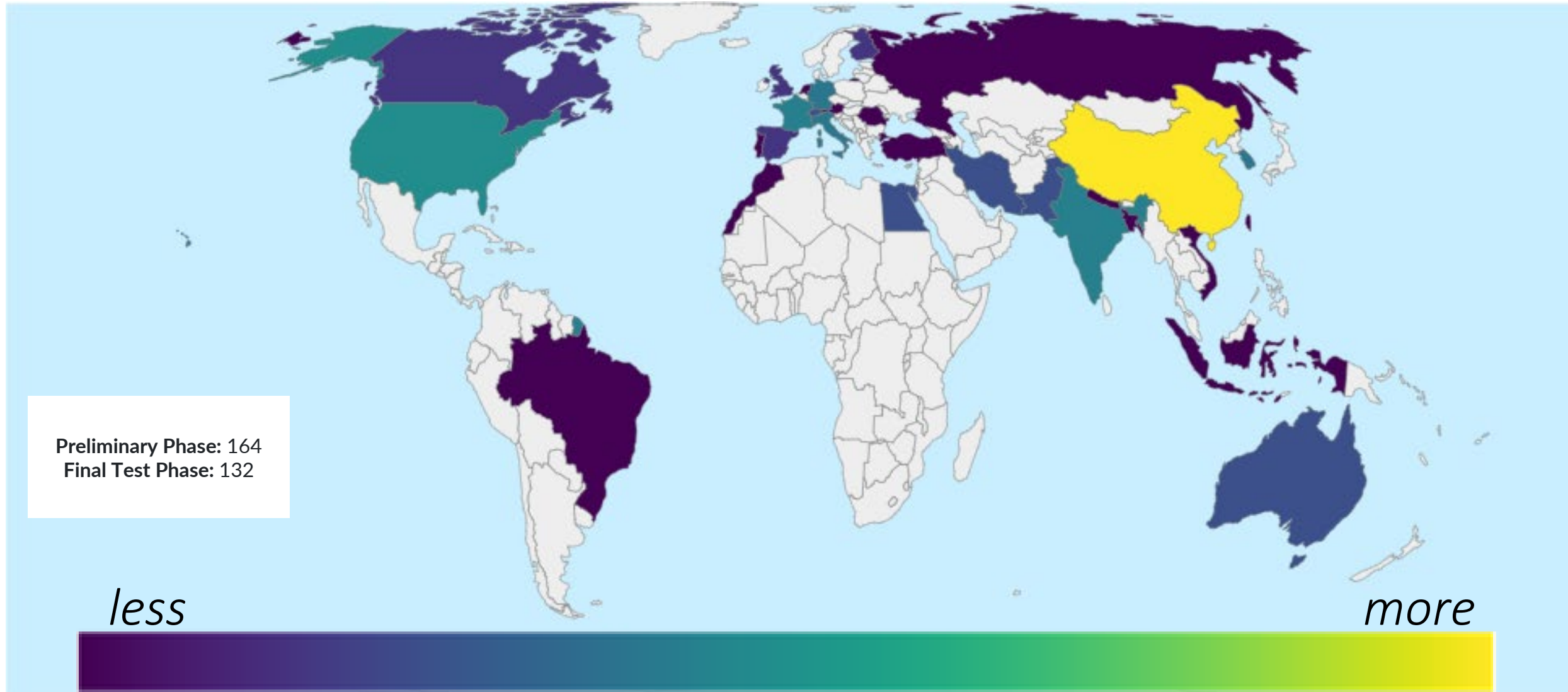


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# Submissions from all over the world!

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Contents lists available at [ScienceDirect](https://www.sciencedirect.com)

# Medical Image Analysis

journal homepage: [www.elsevier.com/locate/media](http://www.elsevier.com/locate/media)



## Multi-Structure Segmentation in CBCT Volumes: the ToothFairy2 Challenge

Federico **Boelli**<sup>a,1,\*</sup>, Luca **Lumetti**<sup>a,1</sup>, Niels **van Nistelrooij**<sup>b,1</sup>, Kevin **Marchesini**<sup>a</sup>, Shankeeth **Vinayahalingam**<sup>b,1</sup>, Mattia **Di Bartolomeo**<sup>c,1</sup>, Arrigo **Pellacani**<sup>d</sup>, Tong **Xi**<sup>b</sup>, Fabian **Isensee**<sup>e,f</sup>, Yannick **Kirchhoff**<sup>f,g</sup>, Klaus H. **Maier-Hein**<sup>f,h</sup>, Lars **Kraemer**<sup>e,f</sup>, Maximilian **Rokuss**<sup>f</sup>, Constantin **Ulrich**<sup>f</sup>, Yuxian **Jiang**<sup>i</sup>, Yusheng **Liu**<sup>i</sup>, Lisheng **Wang**<sup>i</sup>, Haoshen **Wang**<sup>j</sup>, Siyu **Chen**<sup>j</sup>, Zhiming **Cui**<sup>j</sup>, Pengcheng **Shi**<sup>k</sup>, Konstantin **Dmitriev**<sup>l</sup>, Qi **Ma**<sup>m,1</sup>, Ender **Konukoglu**<sup>m</sup>, Marek **Wodzinski**<sup>o,1</sup>, Henning **Müller**<sup>p,1</sup>, Haipeng **Mai**<sup>f</sup>, Xiaobing **Dang**<sup>f</sup>, Ruxu **Du**<sup>f</sup>, Shrajan **Bhandary**<sup>s</sup>, Radu **Grosu**<sup>s</sup>, Zahra **Babaiee**<sup>s</sup>, Abdul **Qayyum**<sup>t</sup>, Imran **Razzak**<sup>u</sup>, Moona **Mazher**<sup>v</sup>, Ajo Babu **George**<sup>w,1</sup>, Siddhesh **Salfale**<sup>y</sup>, Subhamoy **Mandal**<sup>z</sup>, Stefaan **Berge**<sup>'b</sup>, Bram **van Ginneken**<sup>t,1</sup>, Alexandre **Anesi**<sup>u,1,2</sup>, Costantino **Grana**<sup>a,1,2</sup>

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<sup>b</sup>Radboud University Medical Center, Department of Oral and Maxillofacial Surgery, Nijmegen, the Netherlands

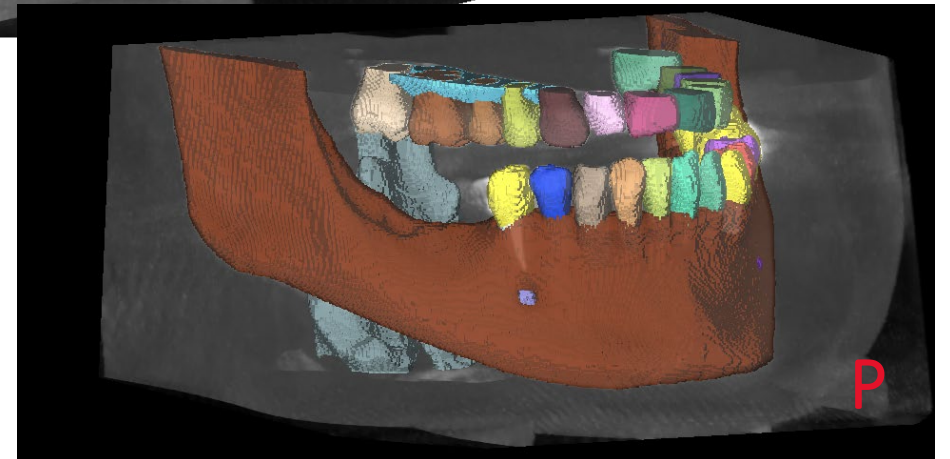
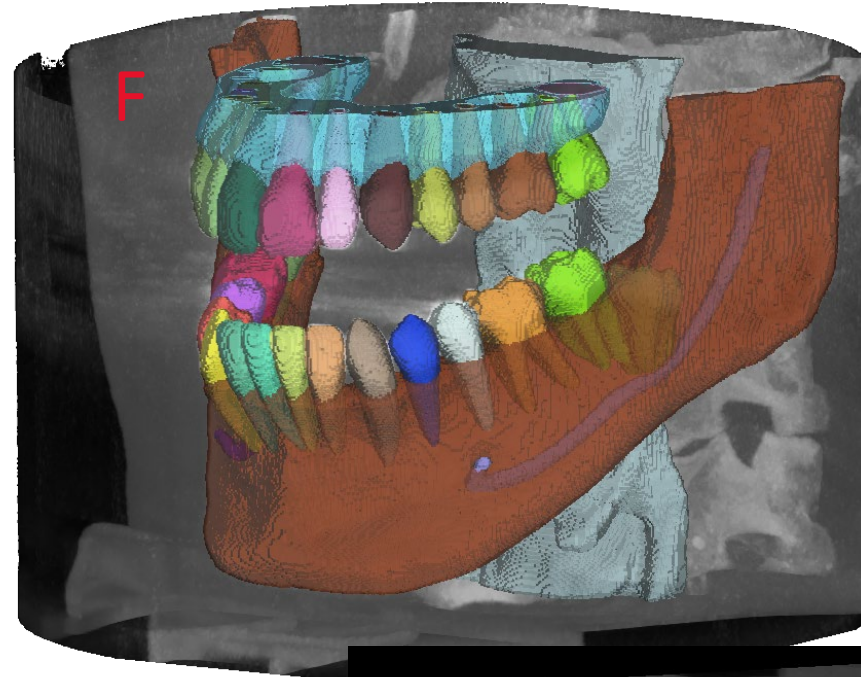
<sup>c</sup>Sapienza University of Rome, Department of Oral and Maxillofacial Sciences, Italy

<sup>d</sup>University of Verona, Unit of Dentistry and Maxillo-Facial Surgery, Surgery, Dentistry, Maternity and Infant Department, Italy

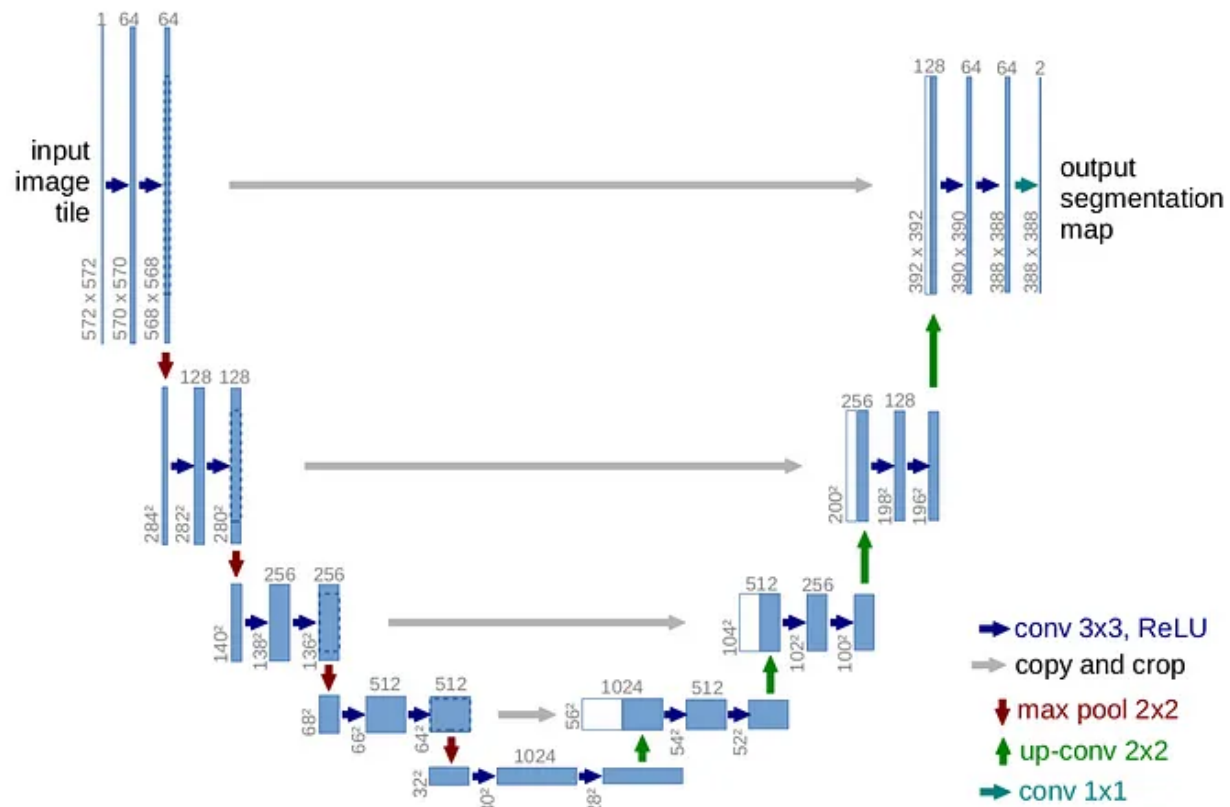
<sup>e</sup>German Cancer Research Center (DKFZ), Helmholtz Imaging, Heidelberg, Germany

<sup>f</sup>German Cancer Research Center (DKFZ), Division of Medical Image Computing, Heidelberg, Germany

- Extension of the ToothFairy Dataset:
  - 🦴 63 more volumes;
  - 📈 40 more classes;
  - 📦 3D annotations on all volumes;
- 480 CBCTs for **training**, 50 **test** volumes from an external institution;
- 42 labeled **classes**;
- **Challenges**:
  - 📄 Large **number** of classes (VRAM requirements);
  - ⚖️ Non-uniform **class distribution** and **missing classes**;
  - 📦 Considerable **difference** in label **sizes**;
  - 👁️ **Varying field of view** (P and F cases).



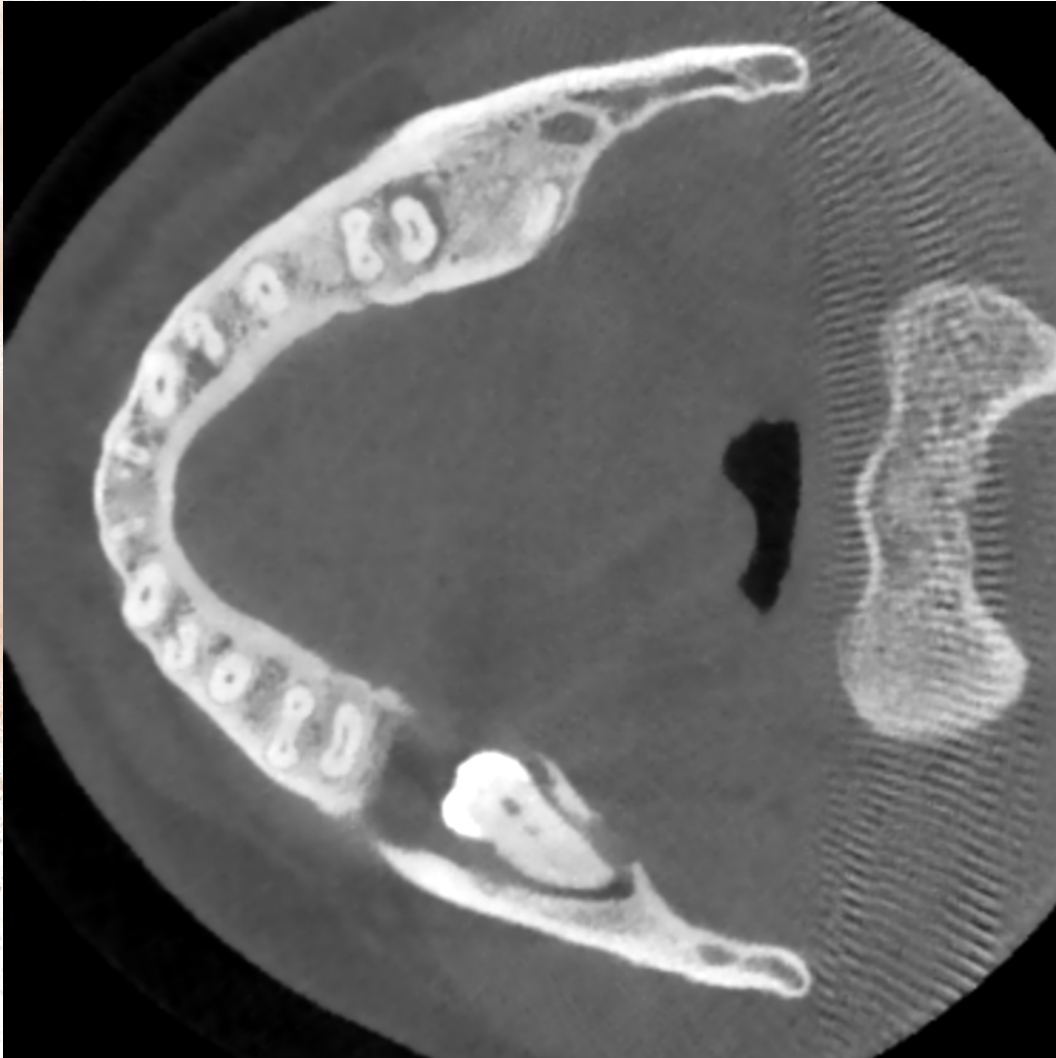
# Submitted Algorithms



- Most of the participants used **Unet** with the **nnUnet** Framework;
- Approaches based on Transformers and other Foundation Models has been proposed as well;

# Submitted Algorithms

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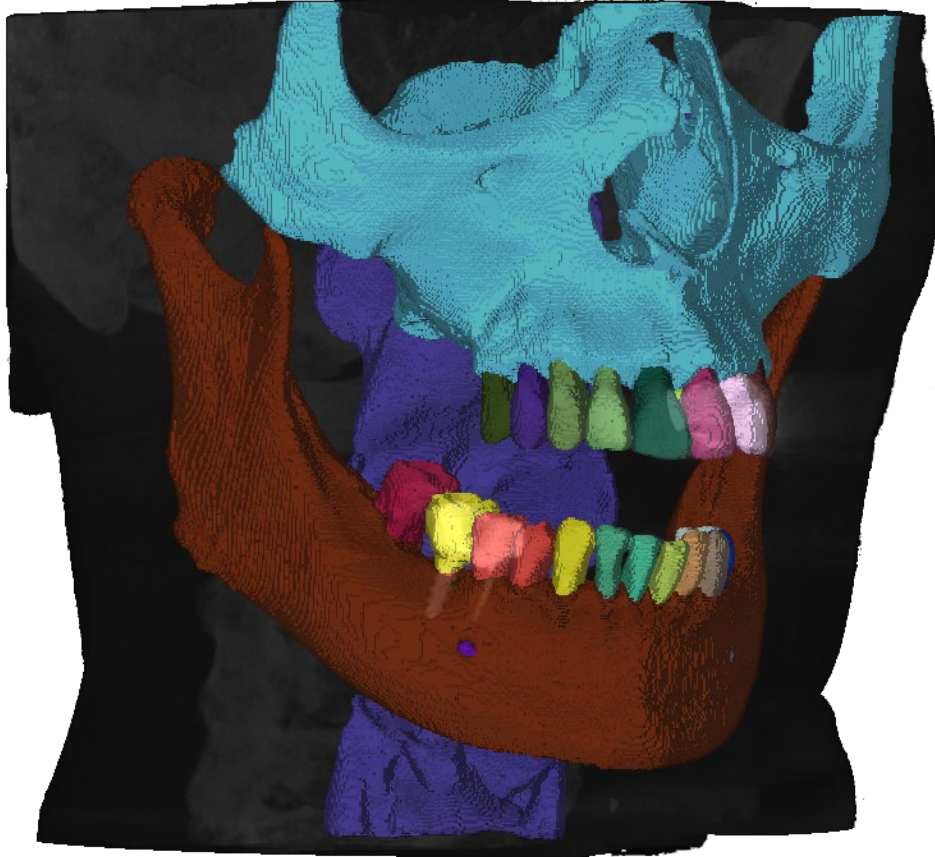


- Most of the participants used Unet with the nnUnet Framework;
- Moderate use of **augmentations**;



# Submitted Algorithms

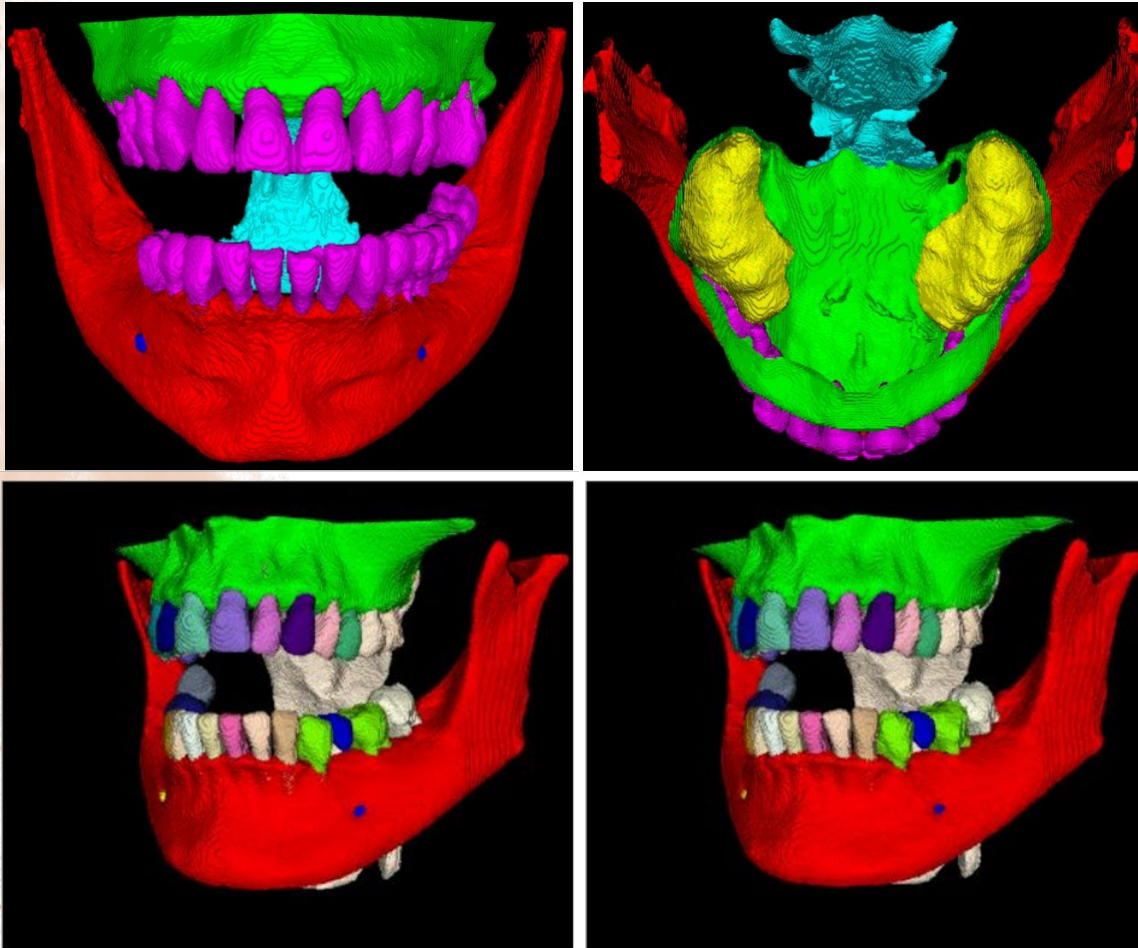
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- Most of the participants used Unet with the nnUnet Framework;
- Moderate use of augmentations;
- **Some** have preprocessed the dataset by removing training samples;

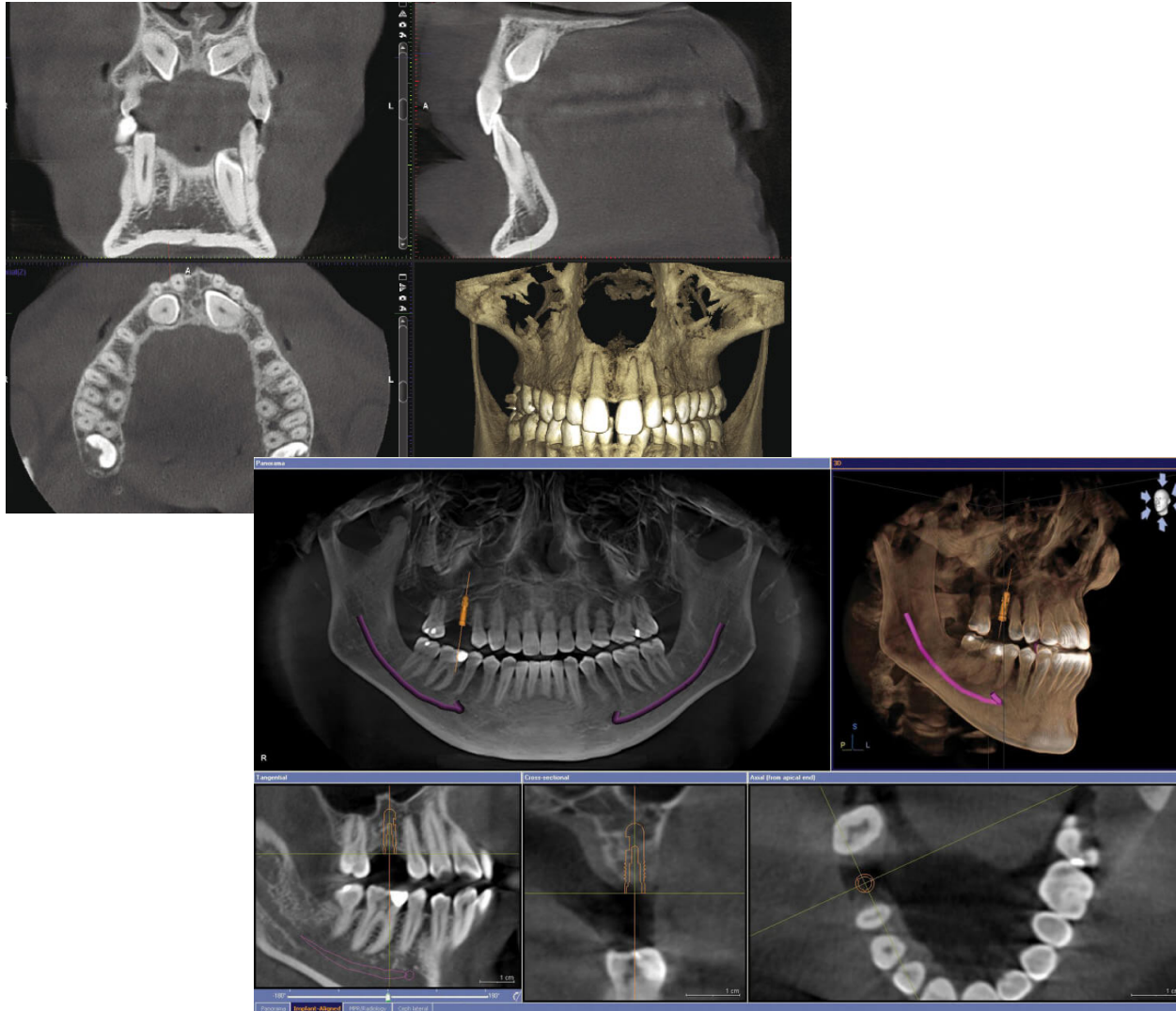
# Submitted Algorithms

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- Most of the participants used Unet with the nnUnet Framework;
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- Some have preprocessed the dataset by removing training samples;
- Some employed a **multi-stage approach**;

# Submitted Algorithms



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- Moderate use of augmentations;
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- Some employed a multi-stage approach;
- As far as we know, **no** one employed external data. Some have tried to pretrain the networks with scarce results;

# Submitted Algorithms

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$$\text{Focal Loss} = -\alpha_i \cdot (1 - p_i)^\gamma \cdot \log(p_i)$$

$$\text{Dice Loss} = 1 - \frac{2 \cdot \sum_i^N (p_i \cdot g_i)}{\sum_{i=1}^N (p_i + g_i)}$$

$$\text{IoU Loss} = 1 - \frac{\sum_i^N (p_i \cdot g_i)}{\sum_{i=1}^N (p_i + g_i - p_i \cdot g_i)}$$

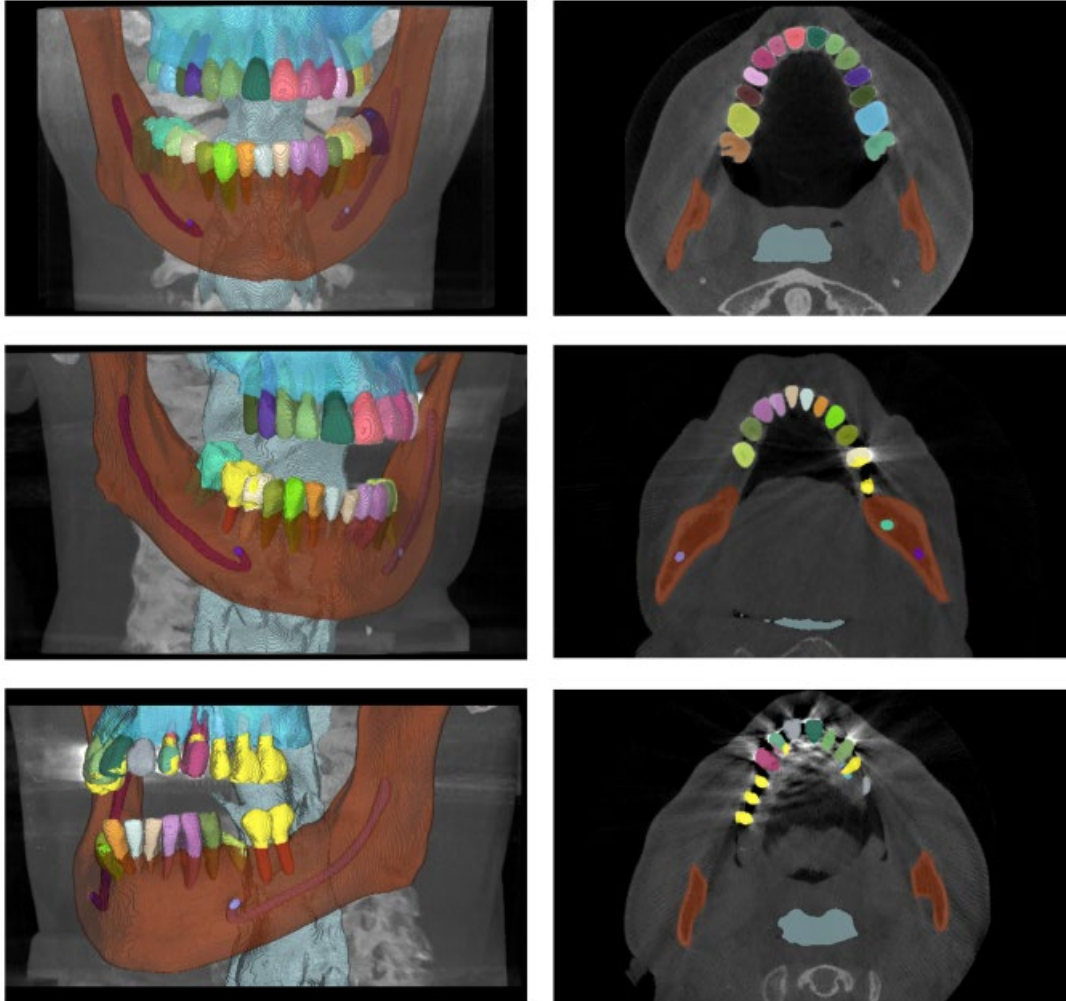
$$\text{CE Loss} = -\frac{1}{N} \sum_{i=1}^N [y_i \cdot \log(p_i) + (1 - y_i) \cdot \log(1 - p_i)]$$

$$\text{Tversky Loss} = \frac{\sum_i^N (p_{0i} \cdot g_{0i})}{\sum_{i=1}^N (p_{0i} \cdot g_{0i}) + \alpha \sum_{i=1}^N (p_{0i} \cdot g_{1i}) + \beta \sum_{i=1}^N (p_{1i} \cdot g_{0i})}$$

- Most of the participants used Unet with the nnUnet Framework;
- Moderate use of augmentations;
- Some have preprocessed the dataset by removing training samples;
- Some employed a multi-stage approach;
- As far as we know, no one employed external data. Some have tried to pretrain the networks with scarce results;
- All **losses** usually employed in **medical imaging** have been **considered**;
- **Almost none** have used a **single loss** but combined two or more;

# Submitted Algorithms

---



- Most of the participants used Unet with the nnUnet Framework;
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- Some have preprocessed the dataset by removing training samples;
- Some employed a multi-stage approach;
- As far as we know, no one employed external data. Some have tried to pretrain the networks with scarce results;
- All losses usually employed in medical imaging have been considered;
- Almost none have used a single loss but combined two or more;
- Many have designed solutions to **filter output predictions**;
- Almost all have used **ensemble**;

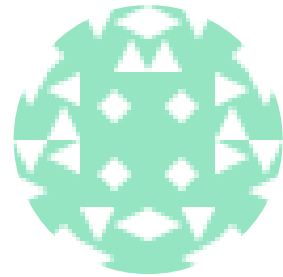
# Final Results

- The final rank is obtained as the average of 94 different rankings;
- Some submissions have been excluded;
- Only the last submission per team has been kept;
- Changing the aggregation mechanism can deeply affect the leaderboard;

#	↑↓ User	↑↓ Algorithm	↑↓ Created	↑↓ Mean Position
1st	YannickKirchhoff	ToothFairy2_Large	16 Aug. 2024	4.6
2nd	Oculins	ToothFairy2_submit	18 Aug. 2024	4.8
3rd	Mors	DentalSeg	10 Aug. 2024	5.2
4th	gaoanqi	toothfairy2_seg	18 Aug. 2024	6.1
5th	shipc1220	NexToU_ToothFairy2	18 Aug. 2024	7.3
6th	sbu_vis	CBCTSegmentation	16 Aug. 2024	7.9
6th	leishen1996	chohotech	18 Aug. 2024	7.9
8th	evyoung	toothfairy	18 Aug. 2024	8.2
9th	pzhhhh	my_toothfairy2	10 Aug. 2024	8.5
10th	2071238	first_try	15 Aug. 2024	8.6
11th	harshitbme	Toothfairy2	18 Aug. 2024	9.9
12th	qimaqi	Toothfairy_Test_Phase	18 Aug. 2024	10.2
13th	huikai	nnuet	18 Aug. 2024	11.1
14th	FUSSEN	FNet_R1	18 Aug. 2024	12.9
15th	IWM	ToothFairySimple	14 Aug. 2024	13.3
16th	ff741333	first_submission	9 Aug. 2024	16.2
17th	laura.daza	DIENTES	16 Aug. 2024	17.7
18th	MaiHaiPeng	ToothFairy2_mai	18 Aug. 2024	19.1
19th	WangXulong	ToothSeg	6 Aug. 2024	19.2
20th	shrajanbhandary	MLC_Unet	18 Aug. 2024	19.8
21st	poiotsy	ToothFairy_pre_single	17 Aug. 2024	19.9
22nd	jing77	toothfair2	18 Aug. 2024	20
23rd	jh.han	ToothFairy2-jh	12 Aug. 2024	20.3
24th	DeepLearnAI	tooth_base_model	18 Aug. 2024	22.5
25th	drajobabu7	ToothFairy2_complete	12 Aug. 2024	24.3
26th	ccy754504392	111	18 Aug. 2024	24.5

# Congratulations to the Winners!

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Yuxian Jiang et al.



Fabian Isensee,  
Yannick Kirchhoff et al.



Haoshen Wang et al.

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3

# TOOTH FAIRY<sup>3</sup>?

