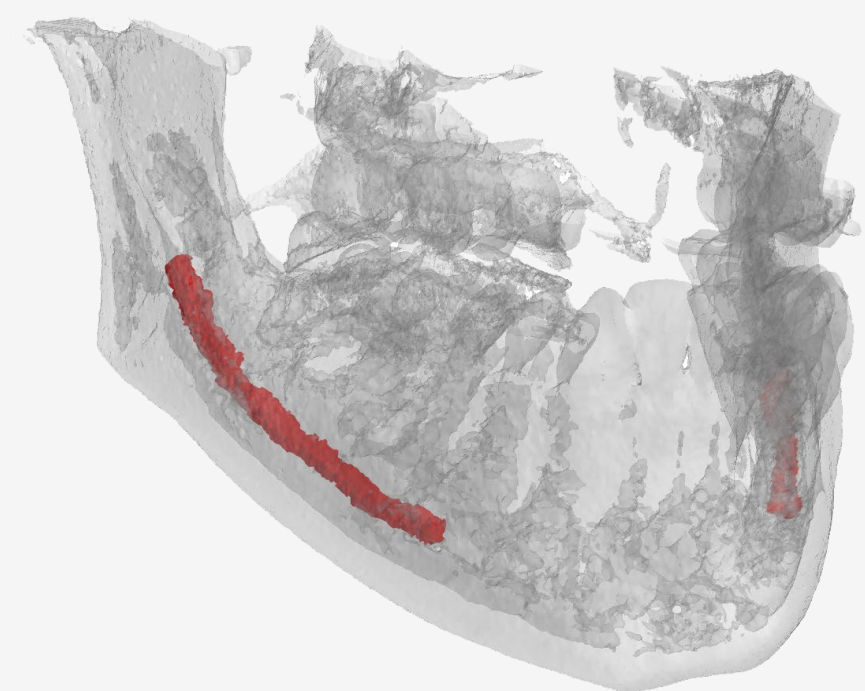


# Improving Segmentation of the Inferior Alveolar Nerve through Deep Label Propagation

Marco Cipriano, Stefano Allegretti, Federico Bolelli, Federico Pollastri, and Costantino Grana  
Department of Engineering “Enzo Ferrari,” University of Modena and Reggio Emilia, Italy

## 1 - The Inferior Alveolar Nerve (IAN)



The position of the **Inferior Alveolar Nerve (IAN)** is essential in surgery operations

**Segmenting** the IAN is a **long and expensive** task: can DNNs help?

Available datasets are **annotated in 2D**: unsuitable for training 3D models

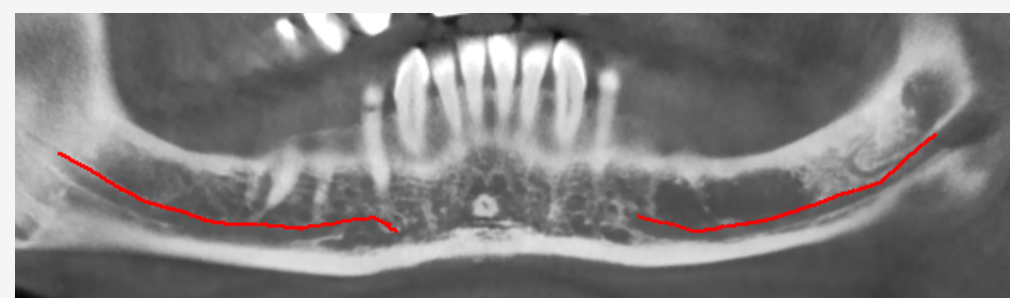
Contributions of this work:

1. A new dataset with **3D annotations** of the IAN
2. **Deep Expansion**: a deep label propagation method to get **3D dense synthetic labels from 2D sparse annotations**
3. Groundbreaking advance in the state of the art of IAN segmentation

## 2 – Available Datasets (2D)

State-of-the-art datasets are **annotated in 2D**:

- The annotation is a **line**, traced on a two-dimensional view (panorex)



- Fast and cheap
- Does not capture the 3D shape of the IAN: not suitable for neural networks

In literature<sup>1</sup>, 2D annotations are turned into 3D with **circle expansion**:

- Trace a cylinder with fixed radius along the 2D annotation

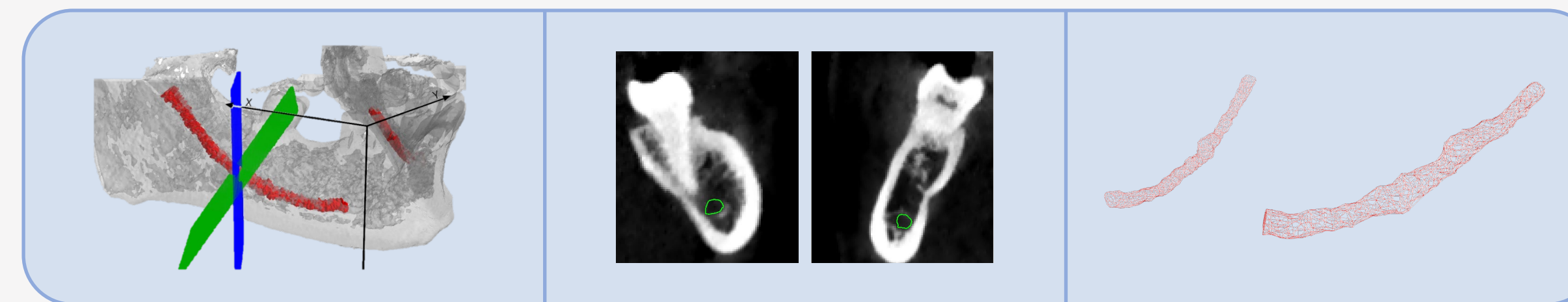


- **Low-quality ground truths** for 3D DNNs

<sup>[1]</sup> Jaskari, J., Sahlsten, J., Järnstedt, J., Mehtonen, H., Karhu, K., Sundqvist, O., Hietanen, A., Varjonen, V., Mattila, V., Kaski, K., *Deep learning method for mandibular canal segmentation in dental cone beam computed tomography volumes*. Scientific reports, 10(1):1–8, 2020

## 3 – Primary Dataset: Manually Annotated

New dataset with **3D dense annotations** of the canal



- Doctors trace **polygons on 2D slices, perpendicular** to the canal
- Polygon vertices are **converted to 3D**
- **$\alpha$ -shape** is used to get a smooth surface

Dataset with **91** densely annotated volumes, **openly released**



## 4 – Secondary Dataset: Deep Expansion

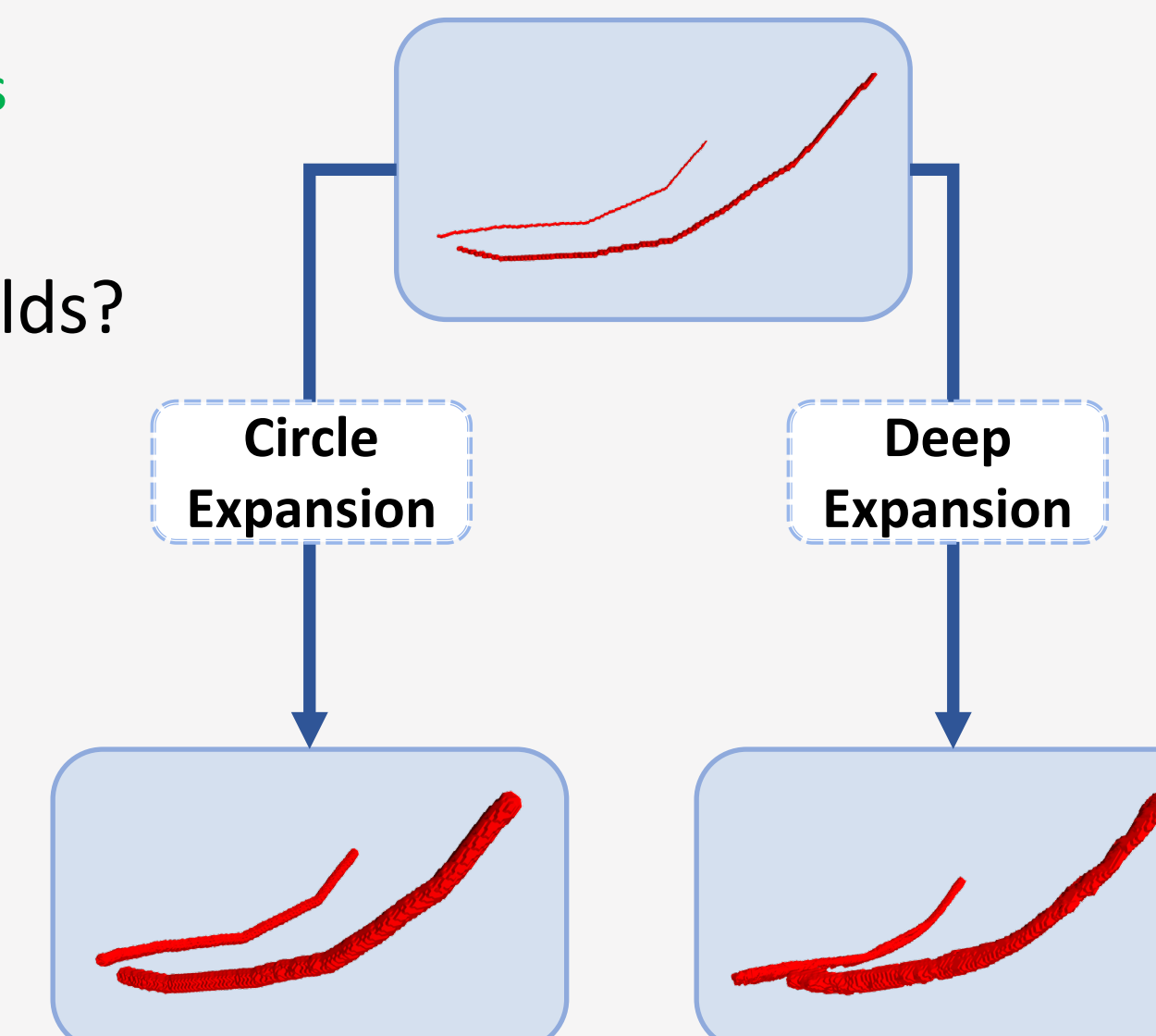
Now we can rely on:

- **Modest** dataset with **3D annotations**
- **Large** datasets with **2D annotations**

Can we have the best of both worlds?

### Deep Expansion

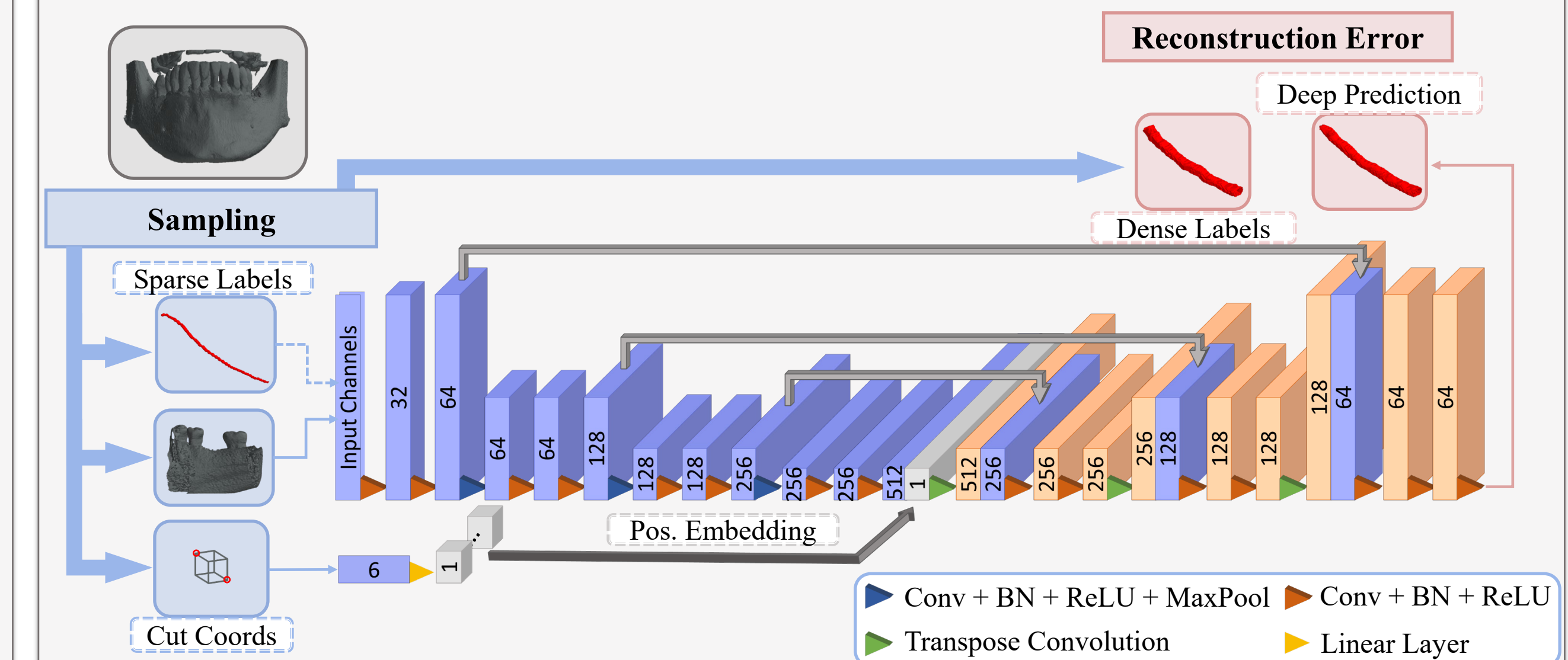
- DNN that gets **3D annotations out of 2D ones**
- **Higher precision** than circle expansion



## 5 – Segmentation Network

### Positional PadUNet

- 3D U-Net with **positional embedding**



## 6 – Experimental Results

New state of the art results

- New model + Primary dataset: **+14 DICE score on the IAN segmentation task**
- New model + Primary dataset + Deep Expansion: **+18 DICE score gain**

Model	Pre-Training Set	Training Set	Dice
Jaskari <i>et al.</i>	-	Cir.Exp.	0.61
PadUNet*	-	Cir.Exp.	0.64
Pos.PadUNet*	-	Cir.Exp.	0.65
PadUNet*	-	3D Ann.	0.73
Pos.PadUNet*	-	3D Ann.	0.75
Pos.PadUNet*	Cir.Exp.	3D Ann.	0.77
Pos.PadUNet*	Deep Expansion*	3D Ann.	<b>0.79</b>

