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Deep recurrent-convolutional model for automated segmentation of craniomaxillofacial CT scans

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Motivation

- Automatically Craniomaxillofacial CT and CBCT segmentation for the diagnosis of CMF malformations
- Challenge:
 - Multiple structures
 - Irregular and complex shape patterns
 - Lack of contrast in joints
 - Significant morphological variations





References

 S. J'egou, M. Drozdzal, D. Vazquez, A. Romero, and Y. Bengio, "The one hundred layers tiramisu: Fully convolutional dense nets for semantic segmentation," in CVPRW 2017. IEEE, 2017, pp. 1175–1183.
J. Hu, L. Shen, and G. Sun, "Squeeze-and-excitation networks," arXiv preprint arXiv:1709.01507, vol. 7, 2017



Method

📋 Convolution 📋 Dense Block 🍘 Residual S&E 🗐 C-LSTM 📋 Transition Down 🗍 Transition Up

- Tiramisù[1]-based Network: fully convolutional DenseNet following U-Net architectures
- C-LSTMs at bottleneck to exploit spatial axial correlation of consecutive scan slices
- Residual squeeze-and-excitation[2] layers to emphasize relevant features and improve representational power

DenseBlock

 $x_1 = H([x_0])$

xo= H([xo,xo])

 $x_3 = H([x_0, x_1, x_2])$

 $x_4 = H[[x_0, x_1, x_2, x_3]]$

[x₀,x₁,x₂,x₃,x₄





Results

New Dataset Released

- MandibleSet: mandible segmentation
- AirwaysSet: nasal cavity and pharynges segmentations

Performance on MICCAI Head and Neck 2015 Datase

Model	Pure DL	DSC (%)
3D-UNet [24]	Yes	87.34
Tiramisu [7]	Yes	91.20
Ours	Yes	93.41
Robust segmentation [26]	No, post-processing	91.00
AnatomyNet [3]	No, post-processing	92.50
Best MICCAI 2015 [27]	No, landmark-guided	93.90
Hierarchical Vertex [25]	No, shape prior	94.00

DSC performance when fine-tuned(second columns) and trained from scratch on the CBCT part of MandibleSet and on the AirwaysSet

Model	Fine-Tuned (%)	Trained from scratch (%)	
	CBCT - Mandible set		
3D-UNet [24]	80.32	73.36	
Tiramisu [7]	83.74	76.78	
Ours	89.25	80.31	
		Airways	
3D-UNet [24]	81.82	77.30	
Tiramisu [7]	84.02	80.21	
Ours	93.31	85.12	

Conclusion

- Improved segmentation performance
- Enanched generalization capabilitier to multiple CMF structures
- Reduced the need of large annotated datasets