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Facial nerve image enhancement from CBCT imaging using supervised learning techniques

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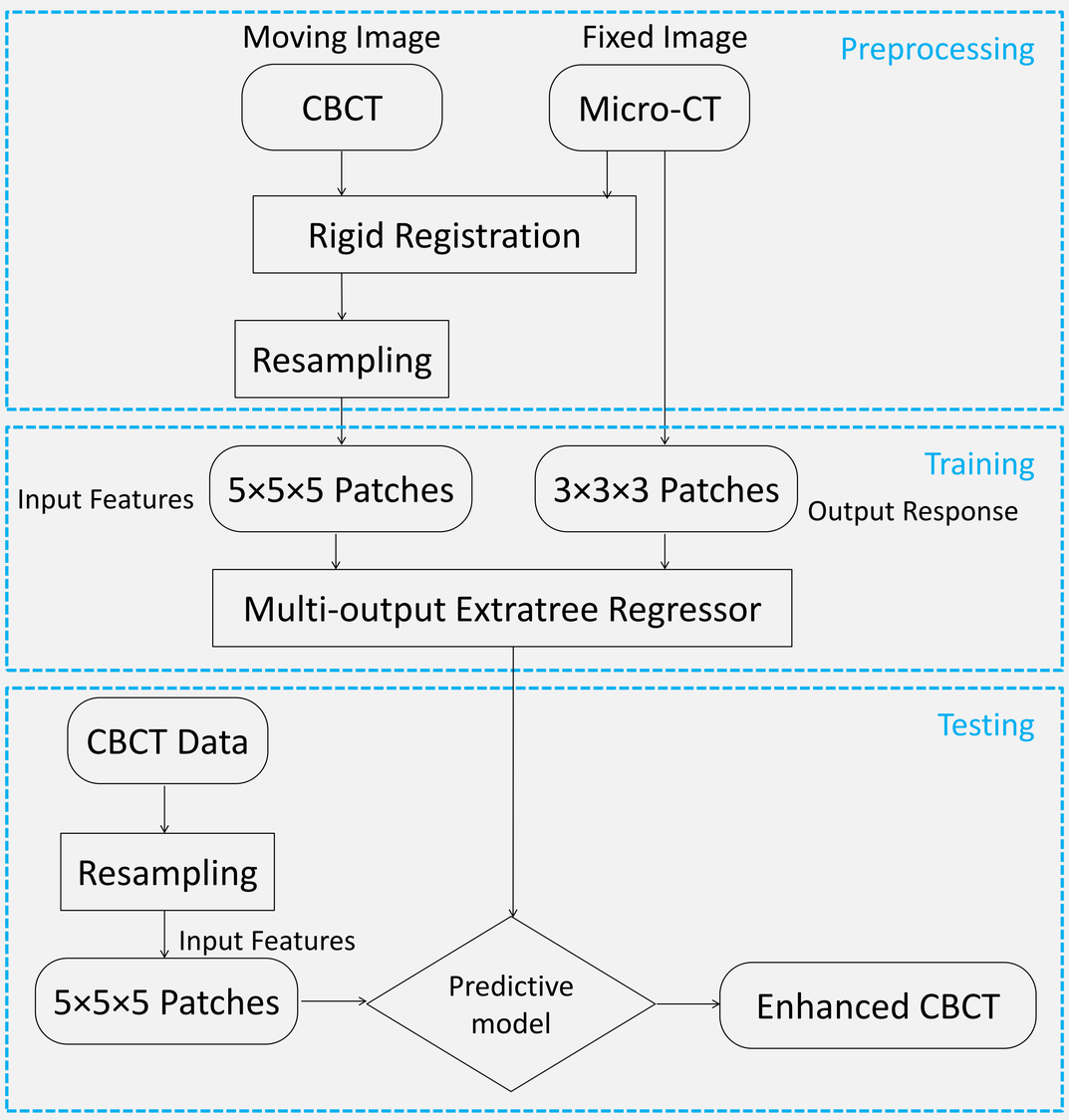
Motivation

- Cochlear implantation (CI) is a treatment for patient suffering from profound hearing loss.
- A surgical planning software, OtoPlan [1], has been developed at the University of Bern for minimally invasive drilling of a cochlear access.
- One of the constraints of the surgical planning during trajectory definition is to avoid the facial nerve with sufficient safety margin.
- Cone-beam computed tomography (CBCT) is used for surgical planning, however, its relatively low resolution renders the identification of the nerve difficult [2].
- In this work, we hypothesize that supervised-learning techniques [3] can be used to enhance the facial nerve in CBCT for more precise surgical planning.

Aim

Our aim is to apply multi-output random regression forests [4] to enhance the CBCT image quality, in order to obtain a more reliable facial nerve segmentation in the framework of preoperative CI planning.

Pipeline & Methods

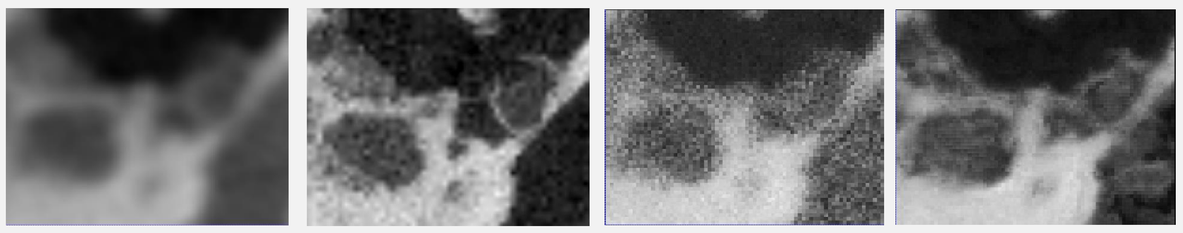


The complete Pipeline

Input Features		
Intensity	**1st Order Statistics**	**GLCM**
	Mean	Energy
	Std.Dev	Entropy
	Skewness	Correlation
	Kurtosis	Inertia
	Minimum	Cluster Shade
	Maximum	Cluster Prominance
		Inverse Difference Moment
		Haralick Correlation

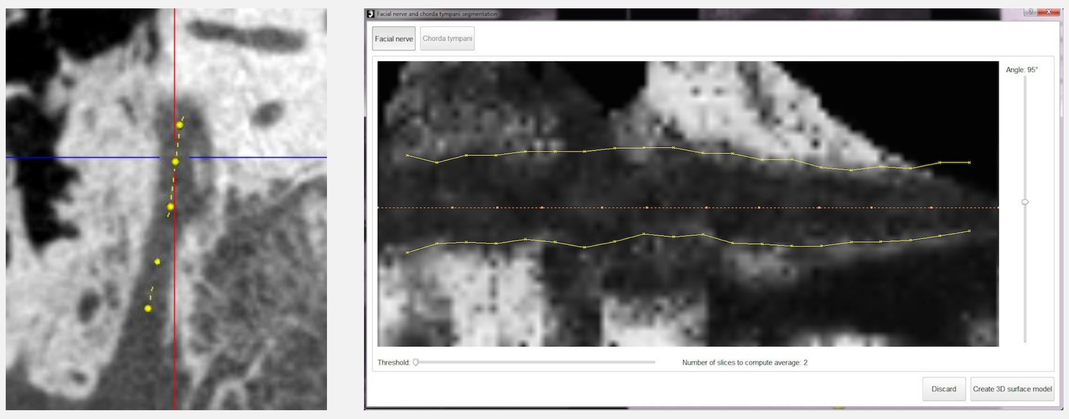
List of intensity texture features computed at each grid node. An initial of 214 texture features were pooled using PCA in order to reduce feature redundancy, resulting in a total of 34 texture features.

Preliminary Results

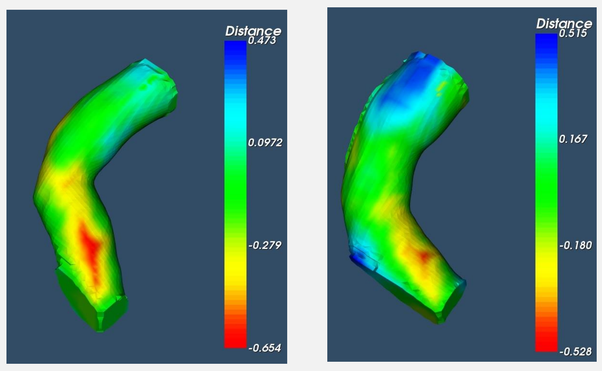


(a) Original CBCT (b) Original micro-CT (c) "short range" prediction (window size 0.072× 0.072mm²) (d) enhanced CBCT (window size 0.288×0.288mm²)

Results of supervised-learning based CBCT image enhancement. Image features are extracted from (a) original CBCT image, and used to produce an enhanced version (d), that presents sharper and more clear structures, as compared to the original high-resolution micro-CT image (b). For demonstration purposes, we report results obtained using features extracted from a short range (i.e. small window size) (c), indicating the ability of the model to learn and utilize local structural information for the prediction process.



OtoPlan panoramic view for semi-automatic segmentation of the facial nerve. The user selects a set of landmarks that approximately correspond to the middle line of the
facial nerve. A threshold based scheme is then used to cast sampling perpendicular in order to find the facial nerve wall (above and below the middle line). Due to the low contrast quality of the CBCT image, manual correction of each point is commonly required. In this example, we illustrate the enhanced CBCT image.



Surface-to-surface distances from the ground-truth segmentation to OtoPlan segmentations generated using the original and enhanced CBCT image. Colormap encodes distances. Best viewed in electronic version.

These first results show the potential of the proposed approach to assist state-of-the- art cochlear surgical planing software, such as OtoPlan, to segment the facial nerve more precisely.

References

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