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#### A Deep Learning-Based Method for Predicting Volumes of Nasopharyngeal Carcinoma for Adaptive Radiation Therapy Treatment

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#### INTRODUCTION

Nasopharyngeal carcinoma (NPC)



## INTRODUCTION

 The anatomical structures of the patient change during the radiation therapy (RT) treatment: shrinkage of NPC, weight loss, displacement or sizes of OARs.





### INTRODUCTION

The timing for re-planning the treatment is hard task and still under debate.

The anatomical changes of NPC and OARs are observed every day or within a few days during RT course.

Re-planning the initial treatment in a bad timing may affect the 2-year survival rates of the patient.

#### Solution:

 ✓ If the future shrinkage of NPC and OARs can be predicted previously, re-planning the current treatment should be made during the RT course.

## **METHODS**

Three components(CNNs, GRUs, global attention model) to predict the target region at <u>week n</u> from <u>week 1 to week n-1</u>.



## **METHODS**

 (n-1)-CNNs are encoder networks to extract the feature of the weekly CT images



## **METHODS**

3D prediction of NPC and OARs obtained by using:

- Weighted voting method (TEP-Net-WV)
- Fully connected layers (TEP-Net-FC)



## DATASET

 Weekly CT images of 140 NPC patients are obtained during 6 weeks of RT course used as training and testing data.

NPC and 5 OARs regions (spinal cord, optic nerve, parotid gland, brainstem and lens) used as <u>teaching labels</u>.



Example of the evolution of NPC (Top row) and OARs (button row) during 6 weeks of RT course

#### **EXPERIMENTAL RESULTS**

#### **NPC results:**



## **EXPERIMENTAL RESULTS**



#### NPC results:

Method	Precision	Recall	DSC		RMSSD	
			Values	<i>p</i> -value	Values	<i>p</i> -value
(a)Week 4						
TEP-Net-FC	$0.87 \pm 0.31$	$0.85 \pm 0.12$	0.86 ± 0.51	-	$1.4 \pm 0.7$	-
TEP-Net-WV	$0.86 \pm 0.22$	$0.82 \pm 0.18$	$0.84 \pm 0.07$	N.S.	$1.5 \pm 1.1$	N.S.
TEP-Net sagittal	$0.84 \pm 0.091$	$0.84 \pm 0.10$	$0.84 \pm 0.09$	< 0.05	$1.4 \pm 0.7$	< 0.05
TEP-Net axial	$0.82 \pm 0.17$	$0.81 \pm 0.15$	$0.81 \pm 0.22$	< 0.05	$1.6 \pm 0.4$	< 0.05
<b>TEP-Net</b> coronal	$0.80 \pm 0.18$	$0.80 \pm 0.23$	$0.80 \pm 0.17$	< 0.05	$1.8 \pm 0.9$	< 0.05
P-net	$0.78 \pm 0.14$	$0.76 \pm 0.21$	$0.77 \pm 0.14$	< 0.05	$2.6 \pm 1.1$	< 0.05
(b)Week 5						
TEP-Net-FC	$0.88 \pm 0.23$	$0.86 \pm 0.25$	$0.87 \pm 0.15$	-	$1.3 \pm 0.7$	-
TEP-Net-WV	$0.85 \pm 0.15$	$0.86 \pm 0.16$	$0.85 \pm 0.41$	N.S.	$1.4 \pm 0.8$	N.S.
<b>TEP-Net</b> sagittal	$0.83 \pm 0.34$	$0.83 \pm 0.16$	$0.83 \pm 0.12$	< 0.05	$1.6 \pm 1.4$	< 0.05
TEP-Net axial	$0.82 \pm 0.09$	$0.83 \pm 0.15$	$0.82 \pm 0.31$	< 0.05	$1.7 \pm 1.5$	< 0.05
<b>TEP-Net</b> coronal	$0.82 \pm 0.12$	$0.82 \pm 0.41$	$0.82 \pm 0.17$	< 0.05	$1.7 \pm 0.9$	< 0.05
P-net	$0.80 \pm 0.12$	$0.80 \pm 0.14$	$0.80 \pm 0.17$	< 0.05	$1.8 \pm 0.9$	< 0.05
(c)Week 6						
TEP-Net-FC	$0.85\pm0.08$	$0.81 \pm 0.27$	$0.83 \pm 0.13$	-	$1.4 \pm 0.7$	-
TEP-Net-WV	$0.82 \pm 0.17$	$0.81 \pm 0.24$	$0.81 \pm 0.19$	N.S.	$1.8 \pm 1.8$	N.S.
<b>TEP-Net</b> sagittal	$0.80 \pm 0.32$	$0.80 \pm 0.12$	$0.80 \pm 0.13$	< 0.05	$1.8 \pm 0.6$	< 0.05
TEP-Net axial	$0.78 \pm 0.33$	$0.80 \pm 0.01$	$0.79 \pm 0.29$	< 0.05	$2.2 \pm 1.4$	< 0.05
<b>TEP-Net</b> coronal	$0.78 \pm 0.11$	$0.78 \pm 0.09$	$0.78 \pm 0.14$	< 0.05	$2.5 \pm 0.2$	< 0.05
P-net	$0.76 \pm 0.32$	$0.74 \pm 0.21$	$0.75 \pm 0.07$	< 0.05	$2.8 \pm 1.2$	< 0.05

Average and standard deviation of the accuracy of predicting NPC regions

#### **EXPERIMENTAL RESULTS** OARs results:



## EXPERIMENTAL RESULTS

#### **OARs results:**

Method	Precision	Recall	DSC		RMSSD	
			Values	<i>p</i> -value	Values	<i>p</i> -value
(a)Week 4						
TEP-Net-FC	$0.87 \pm 0.23$	$0.86\pm0.07$	$0.86 \pm 0.14$	1.	$1.4 \pm 0.9$	-
TEP-Net-WV	$0.78 \pm 0.28$	$0.78 \pm 0.31$	$0.78 \pm 0.22$	N.S.	$2.4 \pm 0.7$	N.S.
TEP-Net sagittal	$0.84 \pm 0.17$	$0.83 \pm 0.32$	$0.83 \pm 0.07$	< 0.05	$1.4 \pm 0.5$	< 0.05
TEP-Net axial	$0.84 \pm 0.12$	$0.82 \pm 0.08$	$0.82 \pm 0.13$	< 0.05	$1.5 \pm 0.9$	< 0.05
TEP-Net coronal	$0.80 \pm 0.23$	$0.80 \pm 0.16$	$0.80 \pm 0.11$	< 0.05	$1.8 \pm 1.7$	< 0.05
P-net	$0.79 \pm 0.44$	$0.79 \pm 0.16$	$0.79 \pm 0.17$	< 0.05	$2.2 \pm 0.9$	< 0.05
(b)Week 5						
TEP-Net-FC	$0.88 \pm 0.21$	$0.87 \pm 0.31$	$0.87 \pm 0.12$	12	$1.3\pm0.5$	12
TEP-Net-WV	$0.85 \pm 0.34$	$0.86 \pm 0.22$	$0.85 \pm 0.40$	N.S.	$1.4 \pm 0.4$	N.S.
<b>TEP-Net</b> sagittal	$0.84 \pm 0.04$	$0.83 \pm 0.09$	$0.83 \pm 0.19$	< 0.05	$1.6 \pm 1.4$	< 0.05
TEP-Net axial	$0.83 \pm 0.29$	$0.83 \pm 0.45$	$0.83 \pm 0.16$	< 0.05	$1.6 \pm 0.8$	< 0.05
TEP-Net coronal	$0.83 \pm 0.13$	$0.83 \pm 0.51$	$0.83 \pm 0.09$	< 0.05	$1.6 \pm 0.5$	< 0.05
P-net	$0.81 \pm 0.04$	$0.81 \pm 0.08$	$0.81 \pm 0.19$	< 0.05	$1.8 \pm 0.8$	< 0.05
(c)Week 6						
TEP-Net-FC	$0.86 \pm 0.21$	$0.82 \pm 0.47$	$0.84 \pm 0.24$	-	$1.5 \pm 1.4$	
TEP-Net-WV	$0.83 \pm 0.18$	$0.82 \pm 0.28$	$0.82 \pm 0.19$	N.S.	$1.7 \pm 0.5$	N.S.
TEP-Net sagittal	$0.81 \pm 0.38$	$0.80 \pm 0.14$	$0.80 \pm 0.23$	< 0.05	$1.8 \pm 1.1$	< 0.05
TEP-Net axial	$0.78 \pm 0.35$	$0.80 \pm 0.29$	$0.79 \pm 0.15$	< 0.05	$2.1 \pm 0.8$	< 0.05
TEP-Net coronal	$0.78 \pm 0.17$	$0.77 \pm 0.21$	$0.77 \pm 0.19$	< 0.05	$2.6 \pm 0.8$	< 0.05
P-net	$0.76 \pm 0.17$	$0.74 \pm 0.23$	$0.75 \pm 0.25$	< 0.05	$2.8 \pm 1.2$	< 0.05

Average and standard deviation of the accuracy of predicting parotid gland regions

#### DISCUSSION



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• High accuracy of predicting NPC and OARs by using TEP-Net-FC

• TEP-Net-FC can predict more robust the OARs with a large size compared with OARs with small size such as optic nerve and lens.

#### **CONCLUSION AND FUTURE WORKS**

- A new method(TEP-Net) for predicting the NPC and 5 OARs regions in week n from three orthogonal CT images obtained in week 1 to week n-1
- TEP-Net-WV and PET-Net-FC are used as integration process to obtain the final NPC and OARs prediction
- TEP-Net-FC predicts NPC and OARs regions in week 4 to 6 more accurately compared with conventional methods.

#### **FUTURE WORKS**

- We will Introduce an integration by CNN with a conveniently loss function
- All OARs regions will be predicted and quantitative evaluations of each OAR accuracy will be reported