Combating Coronary Calcium Scoring Bias for Non-gated CT by Semantic Learning on Gated CT

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Motivation

Coronary artery calcium (CAC) is a strong predictor of cardiovascular events. Quantification of CAC using **non-gated CT** is a preferred and cost-effective method for routine screening for cardiovascular disease, as **it does not increase radiation exposure or economic burden**.

- Due to the lack of electrocardiogram synchronization on non-gated CT scans, it is **difficult to accurately label the true CAC region without motion artifacts**.
- Existing studies are difficult to combat the scoring bias caused by artifacts, which will lead to **poor scoring bias**.
- We developed a new **semantic-prompt scoring siamese network** to combat coronary calcium scoring bias for non-gated CT by semantic learning on gated CT.

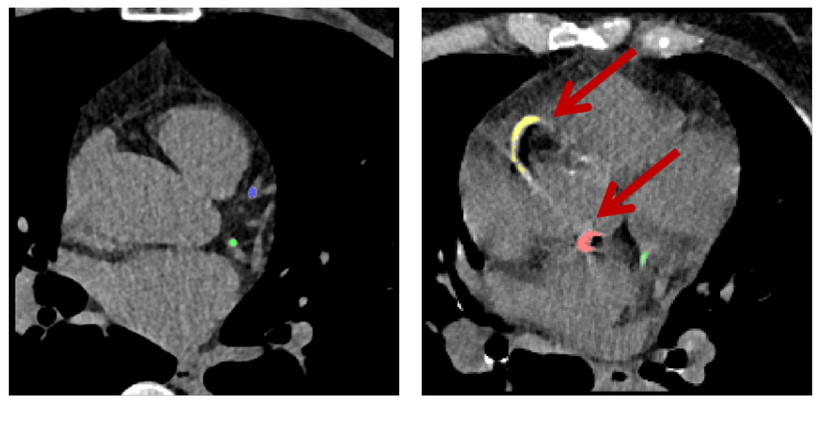

Figure 1. Examples of CAC on gated CT and non-gated CT.

Semantic-Prompt Scoring Siamese Network

We build a shared network with **regression supervised learning** and **semantic supervised learning**. The SPSS is trained using regression supervised learning to predict the Coronary calcium scoring (CCS) of the non-gated CT. To combat the influence of motion artifacts, gated CT scans are used to train the network to learn more accurate semantic features related to CAC.

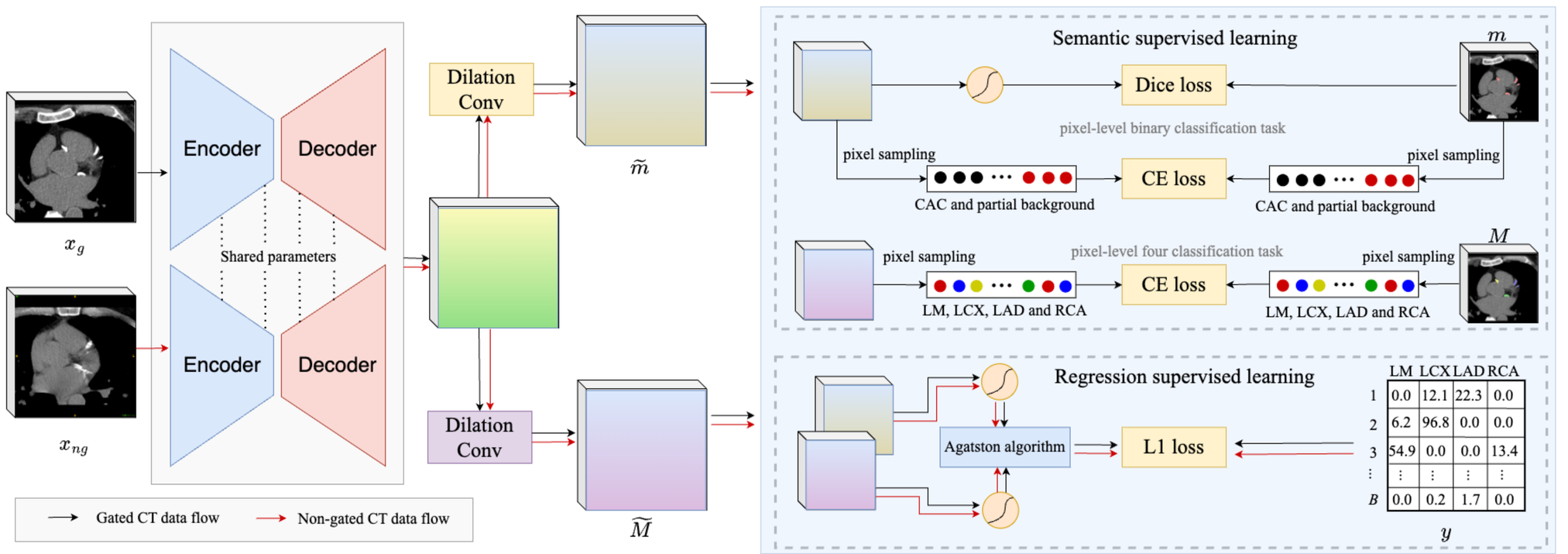

Figure 2. The architecture of our SPSS with semantic supervised learning and regression supervised learning.

Contributions

⇒ We develop a novel semantic-prompt scoring siamese (SPSS) network for CCS of non-gated CT. We cleverly utilize the **semantic calcium information** from gated CT to **combat scoring bias** on non-gated CT.

⇒ This is the **first time** that semantic supervised learning and regression supervised learning have been combined on **non-gated CT without CAC mask**.

⇒ By conducting extensive experiments on publicly available dataset, we demonstrate the superiority of our SPSS compared to its counterparts and establish a **state-of-the-art performance**.

Results

We experiment with four comparable methods to demonstrate the gains of our SPSS, including semantic supervised method **SE-ResNeXt**, regression supervised method **ConvNet**, SPSS with-out semantic supervised learning (SPSS w/o SSL) and our SPSS. By evaluating a public Coronary Calcium and chest CT's (COCA) dataset, our **SPSS establishes a state-of-the-art performance**.

Table 1. Mean error (ME), standard deviation (SD) and Kappa on gated CT and non-gated CT.

Image type	Methods	ME ± SD	Kappa
Gated CT	ConvNet	-19.36 ± 29.45	75.2
	SE-ResNeXt	-2.86 ±	89.0
	SPSS w/o SSL	-4.13 ± 15.28	91.3
	SPSS	**2.31 ± 8.90**	**92.4**
Non-gated CT	ConvNet	23.50 ± 68.42	66.6
	SE-ResNeXt	/	83.6
	SPSS w/o SSL	-26.54 ± 62.64	80.1
	SPSS	**-15.83 ± 44.57**	**85.2**

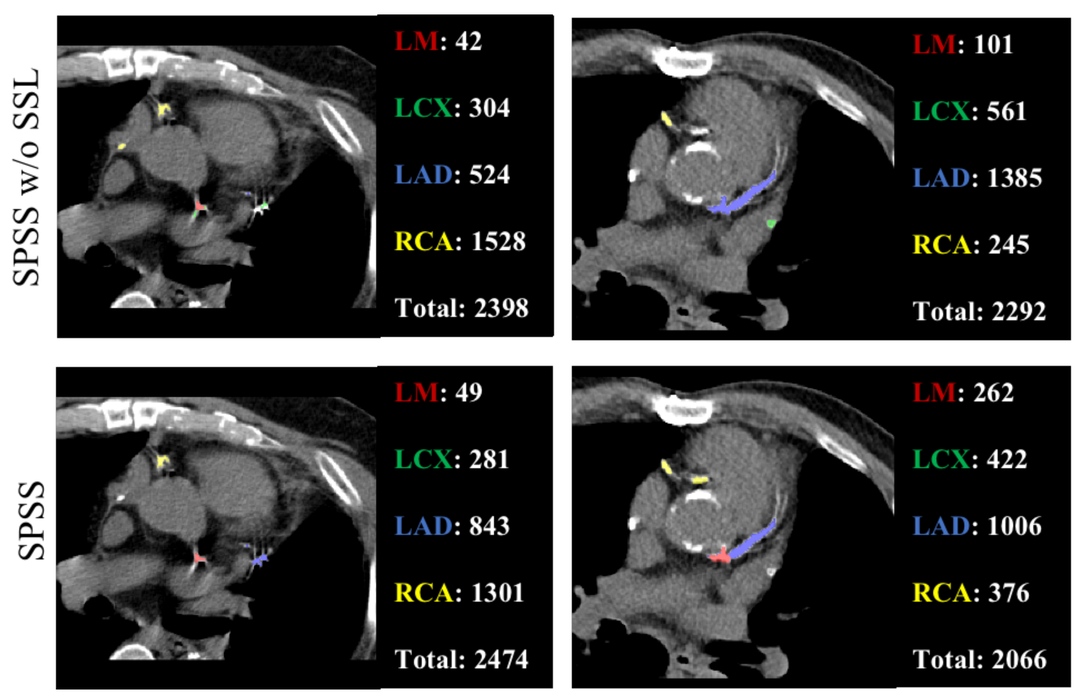

Figure 3. Examples of CAC segmentation and CCS prediction.

Conclusion

We have developed a novel **Semantic-Prompt Scoring Siamese** (SPSS) network for the coronary calcium scoring (CCS) of non-gated CT scans. The SPSS network is trained using **regression supervised learning** to predict the CCS of the non-gated CT scans. To mitigate the impact of motion artifacts, gated CT scans are utilized to train the network to learn more accurate semantic features related to per-artery. By evaluating a public dataset, our SPSS establishes a **state-of-the-art performance**.