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Registration of 2D intraoral radiographs to 3D CBCT using modality-specific encoding

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WHY THIS MATTERS

Preoperative Cone Beam CT (**CBCT**) provides the 3D anatomy for diagnosis and implant planning.

Postoperative Intraoral radiograph (**IOR**) provides high-resolution 2D information, revealing implant position and anatomical changes.

Implant unsafe positioning is highly prevalent (80%) [1]

THE CHALLENGE

IOR-CBCT registration is different from conventional 2D/3D registration:

→ Detector is inside the oral cavity.
→ Strong cross-modality appearance differences.
→ Frequent metal artifacts.
→ Anatomy may change between CBCT/IOR.

No paired IOR-CBCT dataset with known poses.

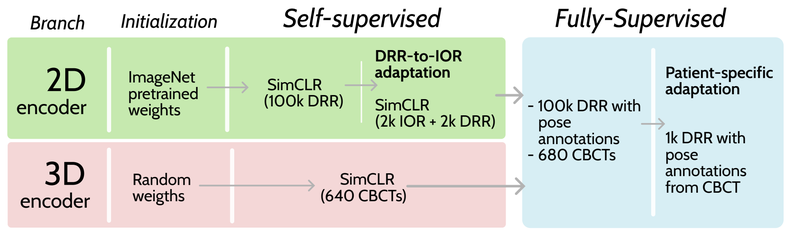
DATASET

839 CBCTs [2,3,4]
167,800 DRRs for training/internal evaluation (Int.).

100 CBCTs [5] → external evaluation (Ext.).

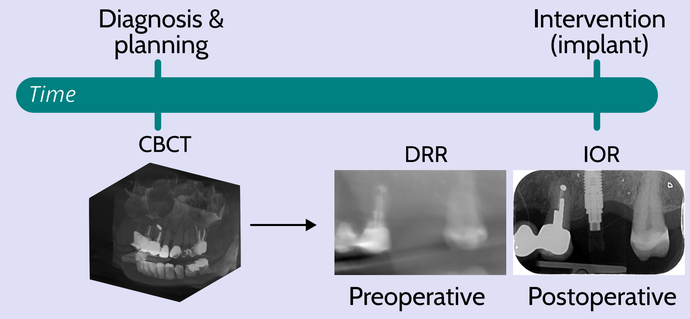
2,050 unpaired IORs
self-supervised 2D pretraining/adaptation

41 paired IOR-CBCT cases → evaluation.
These cases include metal artifacts, implants, and anatomical changes between acquisitions.

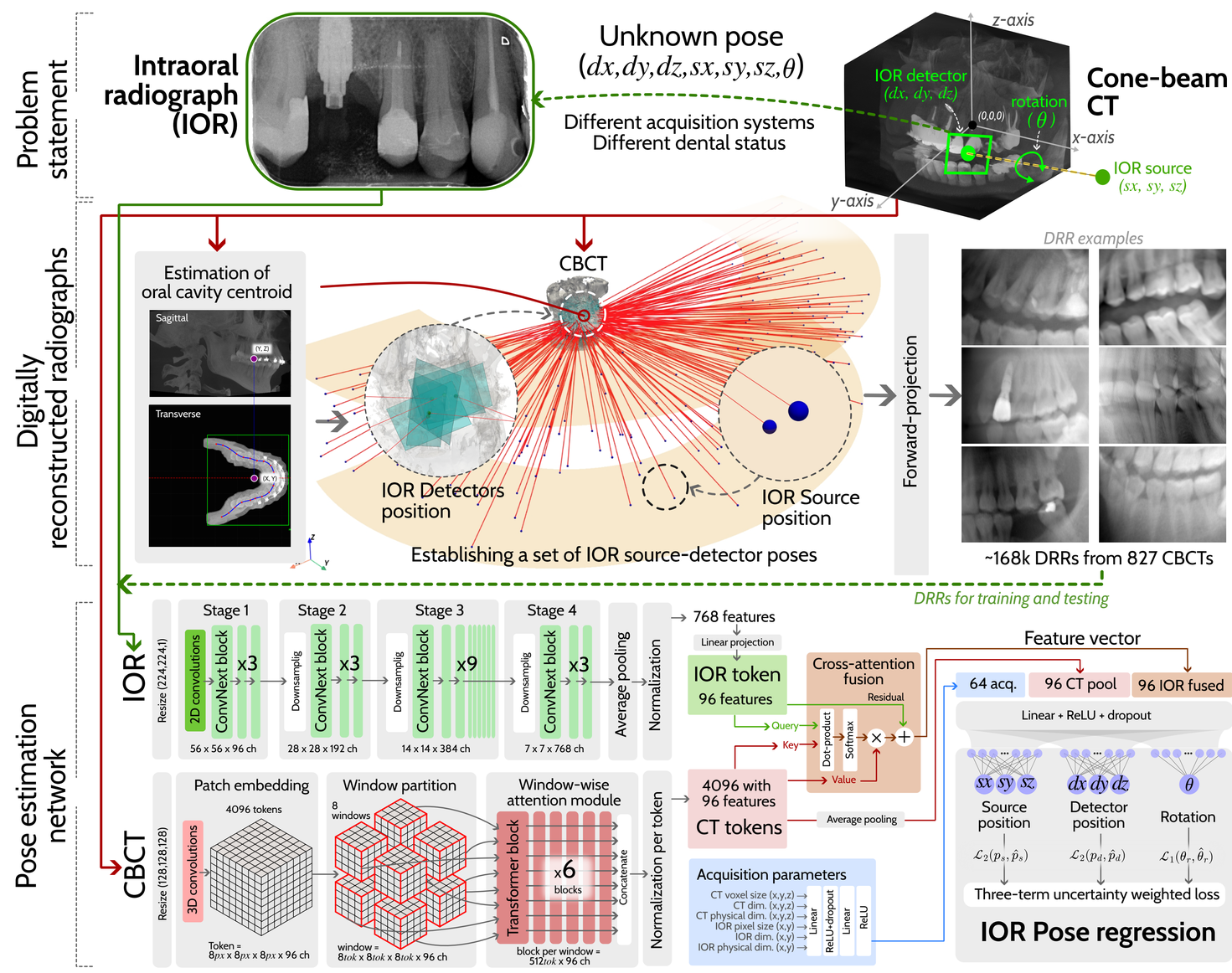


OUR PROPOSAL

Generate a 2D digitally reconstructed radiograph (DRR) in the same IOR imaging pose.



METHODOLOGY



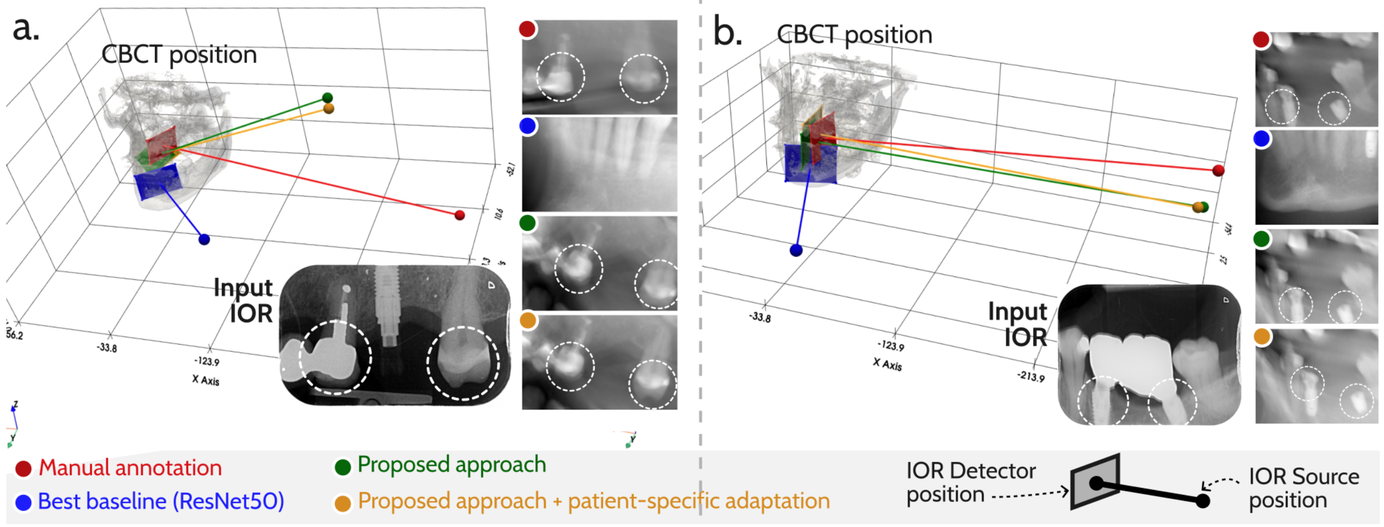
RESULTS

Ablation study: effect of 2D/3D feature branches, ssl, and acquisition parameters (Ap.).

Comparison against baselines on a test partition from the training database (Int.) and an external dataset (Ext.)

	Method	DB.	Source TRE(mm)↓	Source SR(%)↑	Detector TRE(mm)↓	Detector SR(%)↑	Rotation MAE(degrees) ↓
Ablation	2D	*Int.*	38.8	65.3	5.7	40.6	1.5
	2D(*ssl*)	*Int.*	38.7	64.6	5.8	40.8	1.5
	2D(*ssl*)+Ap.	*Int.*	38.6	65.7	5.6	42.3	1.5
	Proposed approach	*Int.*	**38.2**	**65.8**	**3.4**	**71.9**	**1.4**
	2D(*ssl*)+3D(*ssl*)+Ap.	*Ext.*	**40.6**	**63.0**	**5.7**	**40.86**	**1.9**
Baselines	CMAE+MI	*Int.*	356	0	43.6	0.0	11.7
	CMAE+NCC	*Int.*	355	0	38.7	0.24	11.6
	ResNet50	*Int.*	42.8	59.6	6.7	30.9	2.4
		Ext.	47.3	53.8	9.5	13.6	3.0
	Cross-Vit	*Int.*	47.8	53.2	8.6	17.8	3.3
		Ext.	52.0	47.1	11.5	8.2	3.9
	Foundational model (ViT-Large)	*Int.*	43.1	60.6	6.6	31.5	2.7
		Ext.	48.0	53.0	9.5	13.0	3.2

On paired IOR-CBCT data, our method outperformed the best baseline, reducing source error from 192.3 to 119.1 mm, detector error from 34.5 to 20.3 mm, and rotation error from 8.1° to 6.1°.



TAKEAWAYS

Clinicians may benefit from this approach to visually assess, or automatically detect using AI, anatomical changes in IORs relative to stable CBCT anatomy.

REFERENCES

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