Controllable Chest X-Ray Report Generation from Longitudinal Representations

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Motivation

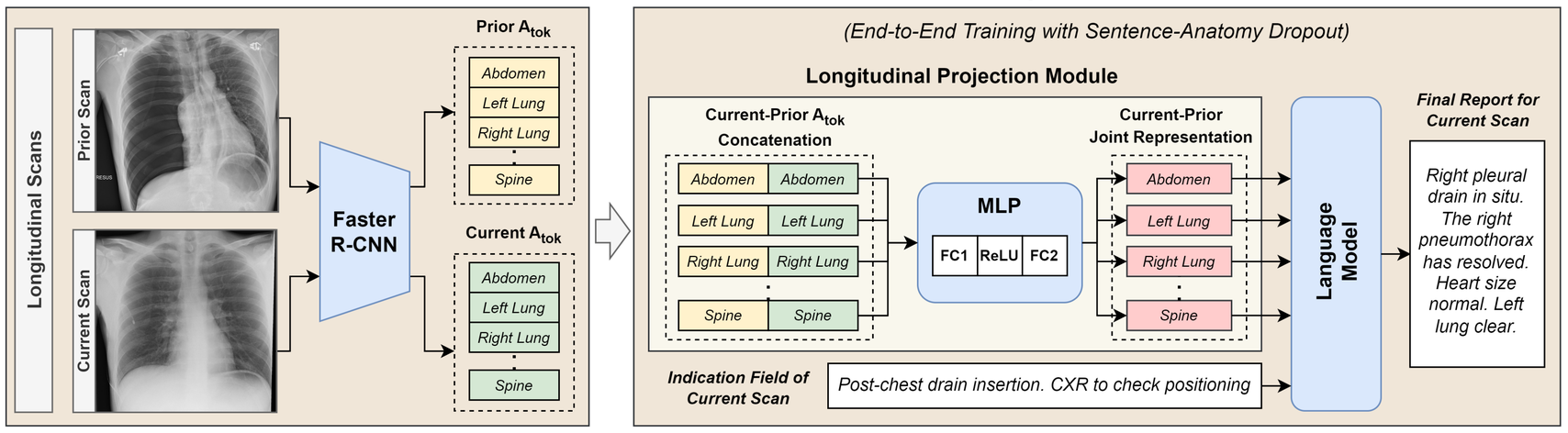
This work focuses on two novel aspects to improve chest X-ray (CXR) **automated reporting**:

- **Longitudinal Representations** – to assess the evolution of the findings over time (*e.g.*, "*New nodular opacity detected in the left lung.*").
- **Controllable Reporting** – to allow the end users to select what anatomical regions in the CXR they want to report on.

Method

➢ Longitudinal Representations

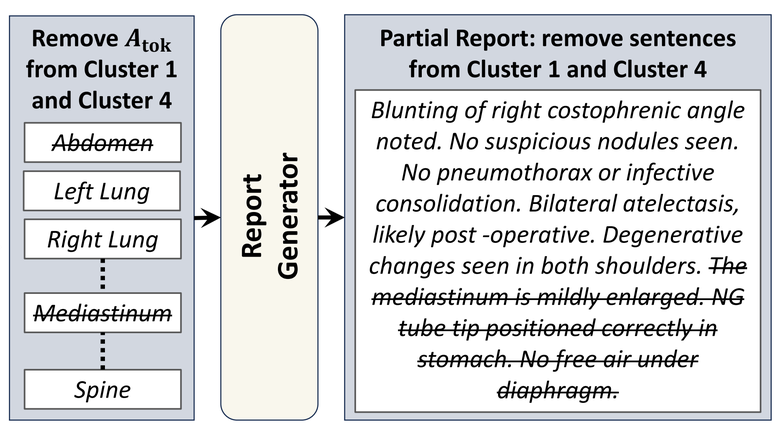
1. Anatomical tokens ($\boldsymbol{A_{tok}}$) for each region present in the current and prior CXRs are extracted using Faster R-CNN [1].
2. The **longitudinal projection module** aligns and projects the two sets of A_{tok} into a joint representation, which is used as the input to the language model.



➢ Controllable Reporting

1. The sentences in a report describing overlapping sets of anatomical regions are clustered.
2. During training, **sentence-anatomy dropout** (SA drop) is applied, where one or more clusters are randomly selected and the corresponding $\mathrm{A_{tok}}$ and the sentences are removed.

	Sentences	Anatomical Regions
Cluster 1	The mediastinum is mildly enlarged	mediastinum
Cluster 2	Blunting of right costophrenic angle noted.	right lung
	No suspicious nodules seen.	right lung, left lung
	No pneumothorax or infective consolidation.	right lung, left lung
	Bilateral atelectasis, likely post -operative.	right lung, left lung
Cluster 3	Degenerative changes seen in both shoulders.	right clavicle, left clavicle
Cluster 4	NG tube tip positioned correctly in stomach.	abdomen
	No free air under diaphragm.	abdomen



Results

	Configuration		CE			NLG			
	Priors	SA drop	F1	P	R	BL-1	BL-4	MTR	RG-L
Baseline →	-	-	0.534	0.593	0.485	0.430	0.224	0.202	0.420
	✓	-	0.548	0.577	**0.522**	0.456	0.239	0.210	**0.428**
	-	✓	0.550	**0.597**	0.510	0.473	0.243	0.213	0.426
Ours →	✓	✓	**0.553**	**0.597**	0.516	**0.486**	**0.246**	**0.216**	0.423

Table 1. Ablation study on incorporating prior CXRs as input and adopting sentence-anatomy dropout during training. We show the results on the MIMIC-CXR test set [2], reporting the Clinical Efficiency metrics (CE) computed using CheXBert [3] and the Natural Language Generations metrics (NLG): BLEU-1, BLEU-4, Meteor, ROUGE-L.

Ground Truth	Baseline	Ours	Comments
There are persisting small to moderate bilateral pleural effusions with subjacent atelectasis as well as pulmonary vascular engorgement and mild interstitial septal thickening. The right infrahilar opacity is unchanged. There is enlargement of the cardiac silhouette unchanged. Calcification of the aortic arch is present.	Moderate to severe cardiomegaly is stable. Moderate bilateral pleural effusions are unchanged. There is mild pulmonary edema. There is no focal consolidation or pneumothorax.	Moderate to large right and small left pleural effusions are unchanged. There is mild pulmonary vascular congestion and interstitial edema. There is a moderate right pleural effusion with associated right lower lobe atelectasis. Moderate cardiomegaly is stable. The aortic knob is calcified. No pneumothorax. No acute osseous abnormalities.	*The report predicted by our method shows a more accurate description of the findings and higher recall compared to the baseline.*
In comparison to the prior chest radiograph all lines and tubes have been removed. The bilateral lung aeration has improved dramatically. There is a small left pleural effusion. There is a subtle right basilar opacity. Heart size is normal. The mediastinal and hilar contours are normal. The pulmonary vasculature is normal. No pneumothorax is seen	Compared to the prior study there is no significant interval change.	Interval removal of the endotracheal tube. The feeding tube has been removed. The right internal jugular catheter has been removed. The cardiomediastinal and hilar contours are within normal limits. The aorta is tortuous. There is a small left pleural effusion with adjacent atelectasis. There is no pneumothorax.	*The report predicted by our method correctly describes the removal of the different tubes.*

Table 2. Qualitative results. We highlight using different colours the segments that are commented on in the right column.

A_{target}	Ground Truth	Baseline	Ours
right hemidiaphragm	Mild elevation of the right hemidiaphragm.	As compared to the previous radiograph there is no relevant change. Elevation of the right hemidiaphragm **with subsequent areas of atelectasis at both lung bases. Borderline size of the cardiac silhouette. No pulmonary edema. No pleural effusions. No pneumonia.**	Elevation of the right hemidiaphragm persists.
abdomen, cardiac silhouette, mediastinum, upper mediastinum	The nasogastric tube has been removed. The heart and mediastinum are within normal limits.	The heart size is normal. The **hilar** and mediastinal contours are normal. **There has been interval resolution of the previously seen small left-sided pneumothorax. There has been slight interval improvement of the previously seen small right pleural effusion. There is no evidence of focal consolidations concerning for pneumonia.**	The nasogastric tube has been removed. The cardiomediastinal silhouette is unremarkable.

Table 3. Qualitative results of partial reports generation, where $\boldsymbol{A_{target}}$ is the subset of anatomical regions we want to report on, which tokens are passed as input to the report generator. We indicate in **red** the hallucination on the missing anatomical regions.

Conclusions

- Longitudinal CXR representations using anatomical alignment allows effective comparison with prior scans.
- Sentence-anatomy dropout strategy allows more control and easier interpretability of the model predictions.

References

[1] Dalla Serra, F., Wang, C., Deligianni, F., Dalton, J., and O'Neil, A.Q.: Finding-Aware Anatomical Tokens for Chest X-Ray Automated Reporting. In: MLMI (2023)
[2] Johnson, A.E., Pollard, T.J., Berkowitz, S.J., Greenbaum, N.R., Lungren, M.P., Deng, CY., Mark, R.G., and Horng, S.: MIMIC-CXR, a de-identified publicly available database of chest radiographs with free-text reports. Scientific Data (2019)
[3] Smit, A., Jain, A., Rajpurkar, P., Pareek, A., Ng, A., and Lungren, M.: Combining Automatic Labelers and Expert Annotations for Accurate Radiology Report Labeling Using BERT. In: EMNLP (2020)