Bootstrapping Chest CT Image Understanding by Distilling Knowledge from X-ray Expert Models

Supplementary Material

6. Extraction of pathology entities

We utilized the CheXpert labeling tool [16] to identify six pathologies within the reports. For each CT report, specific keywords were used to pinpoint six different pathologies, detailed in Table 5. The frequency of each pathology in the ChestCT-16K and ChestCT-EXT datasets is summarized in Table 6.

Pythology	Related key words
Nodule	nodule, nodules, nodular
Opacity	opacity, opacities, decreased translucency, increased density, airspace disease, air-space disease, air space disease, infiltrate, infiltration, interstitial marking, interstitial pattern, interstitial lung, reticular pattern, reticular marking, reticulation, parenchymal scarring, peribronchial thickening, wall thickening, scar
Pleural Effusion	pleural fluid, pleural effusion
Emphysema	emphysema
Inflammation	inflammation, pneumonia, infection, infectious process, infectious
Calcification	calcification, calcifications

Table 5. Keywords for extracting six pathologies.

Pythology	ChestCT-16K			ChestCT-EXT
	Train	Val	Test	Test
Nodule	8084	923	1894	1689
Opacity	6559	757	1489	1347
Pleural Effusion	536	65	120	147
Emphysema	522	57	95	221
Inflammation	1244	139	303	220
Calcification	1826	182	384	290

Table 6. The number of six entities in the ChestCT-16K and ChestCT-EXT datasets.

7. Comparison of different report generation methods using NLP metrics

Table 7 shows the NLP evaluation of our method, consistently outperforming other competitors across all NLP metrics, not only on the internal test set, ChestCT-16K, but also on the external test set, ChestCT-EXT.

Methods	BLEU-4	METEOR	ROUGE-L	CIDEr
Internal test: ChestCT-16K				
R2Gen [5]	7.3	10.4	28.3	7.8
CMN [6]	5.6	8.6	25.5	5.2
RadFM [36]	0.1	4.3	8.6	1.5
BLIP [22]	13.2	19.4	37.9	21.1
DCL [23]	12.5	18.6	37.1	19.0
Ours	**13.8**	**21.3**	**40.2**	**24.4**
External test: ChestCT-EXT				
R2Gen [5]	6.9	10.8	27.1	3.7
CMN [6]	3.2	7.2	21.3	1.7
RadFM [36]	0.1	0.7	1.6	0.2
BLIP [22]	11.2	16.7	33.8	9.6
DCL [23]	10.6	16.4	33.6	9.9
Ours	**12.0**	**17.6**	**35.4**	**10.7**

Table 7. Comparison of NLP metrics of different methods in the ChestCT-16K test set and ChestCT-EXT dataset.

8. Comparison of entity-focused masking (EFM) and random masking

Figure 7 illustrates random masking and the proposed EFM. The panel 'A' displays the original report, while the panel 'B' illustrates the tokenized report using the BERT tokenizer [9], with the '##' symbol indicating the sub-word of the previous one. In the panel B, the highlighted entities are marked in yellow, and the attributes of these entities, such as location, are highlighted in green. The panels 'C1', 'C2', and 'C3' demonstrate examples of the report with tokens randomly masked (indicated by red highlights), compared to the panels 'D1', 'D2', and 'D3', which utilize the EFM for selective masking of reports. The illustration makes it clear that the random masking may obscure words like 'lung' or 'thick' that could be guessed from the surrounding text, whereas EFM masks either an entity or its attributes. This encourages the model to rely more heavily on visual clues from the associated images to predict the masked information.

9. An example of language-guided retrieval

In Figure 8, we present a detailed example of a language-guided retrieval process, which includes a CT query report and the nine most similar X-ray reports. The X-ray report with the highest degree of similarity has a score of 0.963. Symptoms of pleural effusion are present in both of the

A: the conclusion is small amount of inflammation in right upper and lower lung, with scattered focal fibrosis in left lung; old lesions in bilateral lungs; pulmonary air sacs in upper and lower right lung and left lower lung; small pericardial effusion. bilateral thorax was symmetrical, with clear texture of bilateral lung fields, small number of hyperdense patches and nodular opacities in right upper and lower lungs, with scattered stripy opacities in left lung. the right upper and lower lung and left lower lung were bright. Hyperdense nodular opacity in bilateral lungs, with partial calcification. the trachea and main bronchus were unobstructed. Mediastinal mediastinum, no evident enlarged lymph nodes in mediastinum or pulmonary hilus. no evident pleural effusion. no evident thickening of bilateral pleurae. small amount of pericardial effusion.

B: the conclusion is small amount of inflammation in right upper and lower lung, with scattered focal fi ##bro ##sis in left lung; old lesions in bilateral lungs; pulmonary air sac ##s in upper and lower right lung and left lower lung; small per ##ica ##rdial e ##ff ##usion. bilateral thor ##ax was symmetrical, with clear texture of bilateral lung fields, small number of hyper ##den ##se patches and nod ##ular op ##ac ##ities in right upper and lower lungs, with scattered strip ##y op ##ac ##ities in left lung. the right upper and lower lung and left lower lung were bright. Hyper ##den ##se nod ##ular op ##ac ##ity in bilateral lungs, with partial cal ##ci ##fication. the tr ##ache ##a and main bro ##nch ##us were uno ##bs ##truct ##ed. Media ##sti ##nal media ##stin ##um, no evident enlarged l ##ym ##ph nodes in media ##sti ##num or pulmonary hi ##lus. no evident pl ##eur ##al e ##ff ##usion. no evident thick ##ening of bilateral pl ##eur ##ae. small amount of per ##ica ##rdial e ##ff ##usion.

C1: the conclusion is small amount of inflammation in right upper and lower lung, with scattered focal fi ##bro ##sis in left lung; old lesions in bilateral lungs; pulmonary air sac ##s in upper and lower right lung and left lower lung; small per ##ica ##rdial e ##ff ##usion. bilateral thor ##ax was symmetrical, with clear texture of bilateral lung fields, small number of hyper ##den ##se patches and nod ##ular op ##ac ##ities in right upper and lower lungs, with scattered strip ##y op ##ac ##ities in left lung. the right upper and lower lung and left lower lung were bright. Hyper ##den ##se nod ##ular op ##ac ##ity in bilateral lungs, with partial cal ##ci ##fication. the tr ##ache ##a and main bro ##nch ##us were uno ##bs ##truct ##ed. Media ##sti ##nal media ##stin ##um, no evident enlarged l ##ym ##ph nodes in media ##sti ##num or pulmonary hi ##lus. no evident pl ##eur ##al e ##ff ##usion. no evident thick ##ening of bilateral pl ##eur ##ae. small amount of per ##ica ##rdial e ##ff ##usion.

C2: the conclusion is small amount of inflammation in right upper and lower lung, with scattered focal fi ##bro ##sis in left lung; old lesions in bilateral lungs; pulmonary air sac ##s in upper and lower right lung and left lower lung; small per ##ica ##rdial e ##ff ##usion. bilateral thor ##ax was symmetrical, with clear texture of bilateral lung fields, small number of hyper ##den ##se patches and nod ##ular op ##ac ##ities in right upper and lower lungs, with scattered strip ##y op ##ac ##ities in left lung. the right upper and lower lung and left lower lung were bright. Hyper ##den ##se nod ##ular op ##ac ##ity in bilateral lungs, with partial cal ##ci ##fication. the tr ##ache ##a and main bro ##nch ##us were uno ##bs ##truct ##ed. Media ##sti ##nal media ##stin ##um, no evident enlarged l ##ym ##ph nodes in media ##sti ##num or pulmonary hi ##lus. no evident pl ##eur ##al e ##ff ##usion. no evident thick ##ening of bilateral pl ##eur ##ae. small amount of per ##ica ##rdial e ##ff ##usion.

C3: the conclusion is small amount of inflammation in right upper and lower lung, with scattered focal fi ##bro ##sis in left lung; old lesions in bilateral lungs; pulmonary air sac ##s in upper and lower right lung and left lower lung; small per ##ica ##rdial e ##ff ##usion. bilateral thor ##ax was symmetrical, with clear texture of bilateral lung fields, small number of hyper ##den ##se patches and nod ##ular op ##ac ##ities in right upper and lower lungs, with scattered strip ##y op ##ac ##ities in left lung. the right upper and lower lung and left lower lung were bright. Hyper ##den ##se nod ##ular op ##ac ##ity in bilateral lungs, with partial cal ##ci ##fication. the tr ##ache ##a and main bro ##nch ##us were uno ##bs ##truct ##ed. Media ##sti ##nal media ##stin ##um, no evident enlarged l ##ym ##ph nodes in media ##sti ##num or pulmonary hi ##lus. no evident pl ##eur ##al e ##ff ##usion. no evident thick ##ening of bilateral pl ##eur ##ae. small amount of per ##ica ##rdial e ##ff ##usion.

D1: the conclusion is small amount of inflammation in right upper and lower lung, with scattered focal fi ##bro ##sis in left lung; old lesions in bilateral lungs; pulmonary air sac ##s in upper and lower right lung and left lower lung; small per ##ica ##rdial e ##ff ##usion. bilateral thor ##ax was symmetrical, with clear texture of bilateral lung fields, small number of hyper ##den ##se patches and nod ##ular op ##ac ##ities in right upper and lower lungs, with scattered strip ##y op ##ac ##ities in left lung. the right upper and lower lung and left lower lung were bright. Hyper ##den ##se nod ##ular op ##ac ##ity in bilateral lungs, with partial cal ##ci ##fication. the tr ##ache ##a and main bro ##nch ##us were uno ##bs ##truct ##ed. Media ##sti ##nal media ##stin ##um, no evident enlarged l ##ym ##ph nodes in media ##sti ##num or pulmonary hi ##lus. no evident pl ##eur ##al e ##ff ##usion. no evident thick ##ening of bilateral pl ##eur ##ae. small amount of per ##ica ##rdial e ##ff ##usion.

D2: the conclusion is small amount of inflammation in right upper and lower lung, with scattered focal fi ##bro ##sis in left lung; old lesions in bilateral lungs; pulmonary air sac ##s in upper and lower right lung and left lower lung; small per ##ica ##rdial e ##ff ##usion. bilateral thor ##ax was symmetrical, with clear texture of bilateral lung fields, small number of hyper ##den ##se patches and nod ##ular op ##ac ##ities in right upper and lower lungs, with scattered strip ##y op ##ac ##ities in left lung. the right upper and lower lung and left lower lung were bright. Hyper ##den ##se nod ##ular op ##ac ##ity in bilateral lungs, with partial cal ##ci ##fication. the tr ##ache ##a and main bro ##nch ##us were uno ##bs ##truct ##ed. Media ##sti ##nal media ##stin ##um, no evident enlarged l ##ym ##ph nodes in media ##sti ##num or pulmonary hi ##lus. no evident pl ##eur ##al e ##ff ##usion. no evident thick ##ening of bilateral pl ##eur ##ae. small amount of per ##ica ##rdial e ##ff ##usion.

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Figure 7. Comparison of random masking and our proposed entity-focused masking.

matching images. This retrieval method, which is based on the similarity of reports, can effectively identify the X-ray image that best matches each CT image query.

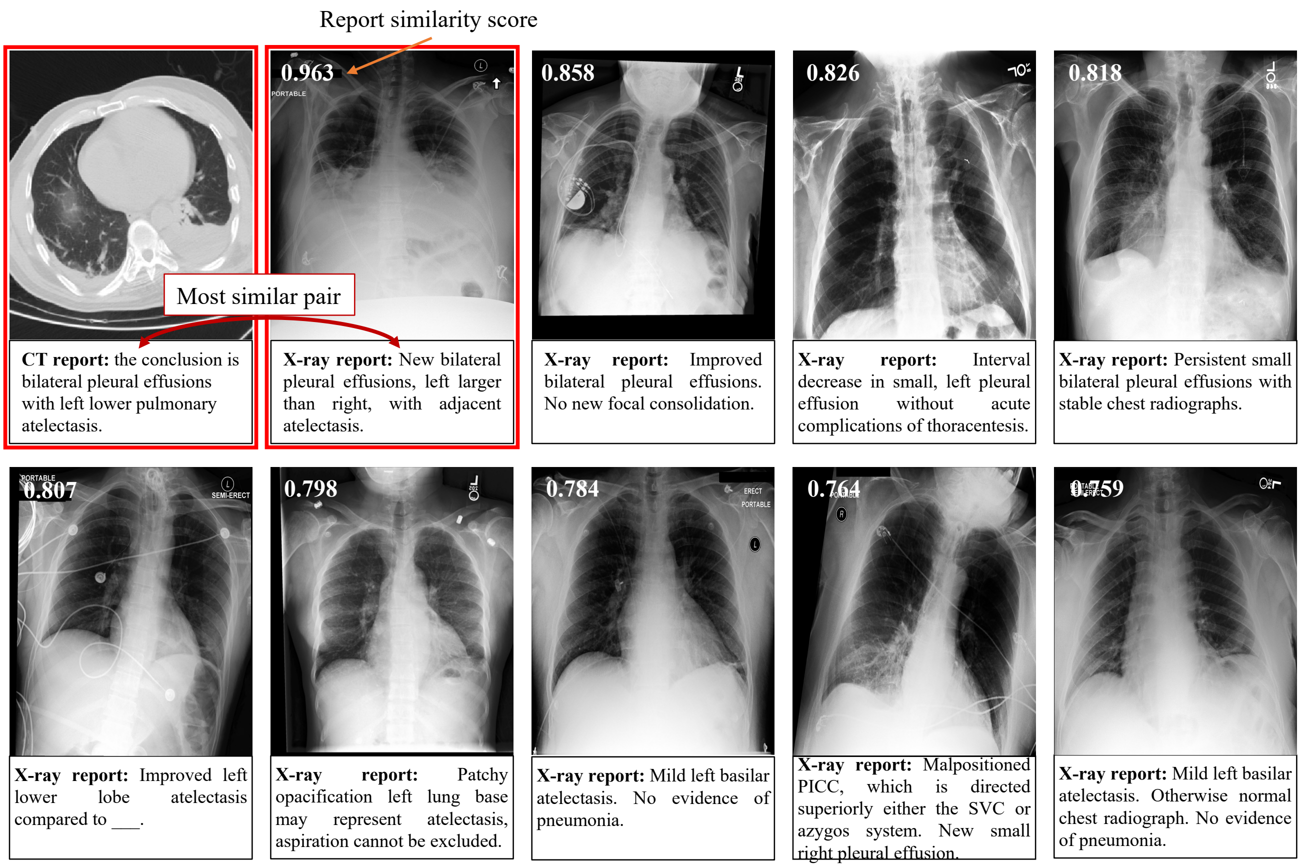

Figure 8. An example of language-guided report retrieval.