

透過物件偵測和高級語言模型自動生成副甲狀腺病灶報告

Automated Generation of Parathyroid Lesion Reports via Object Detection and Advanced Language Modeling

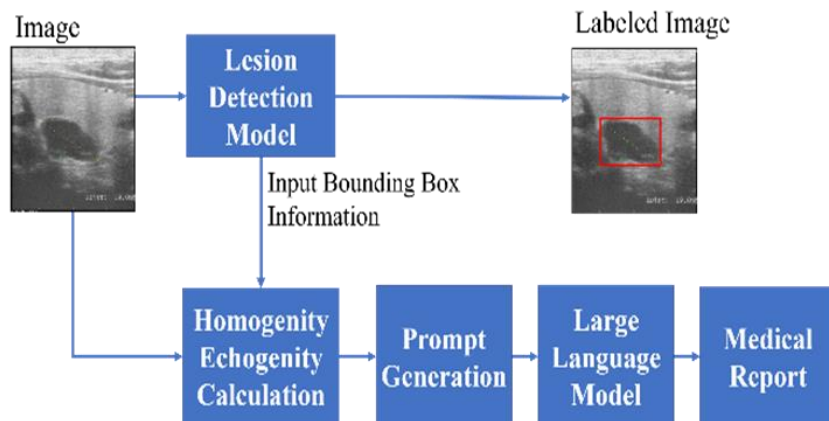
研究生：資訊工程系 許至欒

指導教授：資訊工程系 張傳育特聘教授

摘要

在超音波影像中，不同組織和結構會產生不同的聲波反射，形成黑白灰階影像。臨床上，放射科醫師會根據病灶的大小、形狀和結構，撰寫醫療報告。然而放射科醫師每天需要看非常多的影像，這項工作不僅繁雜且需要醫師保持專注，諸多因素皆有可能導致對於醫療報告出現不同的判斷。本研究提出了 UltraPTGPT，首先會利用 YOLOv7 進行位置記號圖示以及病灶辨識，接著計算影像的均質性與回音性，結合 Bounding Box 等資訊產出 Prompt，輸入進大型語言模型 Vicuna 來生成醫療報告。本系統會根據輸入的副甲狀腺超音波影像生成醫療報告資訊，避免不同醫師因為經驗不足或是精神狀況不佳而導致誤判或漏判。本系統除了能提供具有標記框的超音波影像，還能提供相對應影像中的醫療報告的文字描述，減輕臨床醫師對於報告書寫的負擔，為臨床醫學帶來更全面的輔助。實驗結果顯示，在病灶辨識的測試集當中，在 K-Fold 的驗證中得到了 91.04% 的 mAP；在醫療報告的生成中，我們的方法與 MiniGPT 相比，利用 Cosine Similarity、ROUGE 以及 BLEU 的計算加上醫師的評估回饋，我們能夠生成更高相似值的醫療報告。

研究方法



本論文利用物件偵測技術在超音波影像中進行病灶的定位以及分類，類別總共分為 Mass、Nodule、Cyst 三種，並利用物件偵測模型輸出的標記框資訊加上後續影像處理技術的結合，生成出作為輸入進大型語言模型的 Prompt，最後利用經過微調的專門針對副甲狀腺的大型語言模型，進行醫療報告的生成，來達到減輕臨床醫師對於報告書寫的負擔，進而能夠讓醫師更專注於臨床的判斷，為臨床醫學帶來更全面的輔助。

實驗結果

病灶分類比較

model	ViT meanAcc	YOLOv5 meanAcc	YOLOv7 meanAcc	ConvNext meanAcc	Geometric Transformation meanAcc	YOLOv7BiFPN meanAcc
train1234test5	66.89%	81.97%	85.25%	88.38%	81.21%	88.85%
train1235test4	75.25%	85.48%	87.13%	93.58%	85.51%	94.72%
train1245test3	70.16%	86.23%	86.23%	89.81%	83.87%	92.79%
train1345test2	74.67%	85.53%	86.84%	92.82%	85.89%	91.45%
train2345test1	66.23%	84.59%	86.89%	87.1%	78.27%	93.77%
Average	70.64%	84.76%	86.47%	90.34%	82.95%	93.32%

病灶物件偵測比較

model	ViT mAP	YOLOv5 mAP	YOLOv7 mAP	ConvNext mAP	Geometric Transformation mAP	YOLOv7BiFPN mAP
train1234test5	65.21%	85.12%	85.11%	86.45%	78.53%	90.4%
train1235test4	73.66%	86.48%	85.58%	90.79%	83.58%	92.57%
train1245test3	67.78%	85.51%	85.44%	88.23%	81.36%	90.55%
train1345test2	72.56%	87.19%	86.38%	90.26%	83.27%	91.96%
train2345test1	64.38%	82.66%	85.08%	85.42%	76.64%	89.72%
Average	68.72%	85.39%	85.52%	88.19%	80.68%	91.04%

位置記號圖示辨識比較

	YOLOv5 mAP	YOLO7 mAP	YOLOv7BiFPN mAP
Test5	98.05%	98.21%	99.58%
Test4	98.88%	99.36%	99.63%
Test3	99.02%	98.86%	99.71%
Test2	98.02%	98.14%	99.47%
Test1	98.85%	99.11%	99.86%
Average	98.56%	98.74%	99.65% (+0.91%)

GPT 生成醫療報告評分比較

	MiniGPT1522			Our Way1522			MiniGPT15220		
	CS	ROUG	BLEU	CS	ROUG	BLEU	CS	ROUG	BLEU
Case 1	0.83	0.84	0.67	0.63	0.81	0.42	0.41	0.40	0.03
Case 2	0.45	0.48	0.06	0.60	0.78	0.39	0.26	0.38	0.02
Case 3	0.33	0.17	0.02	0.30	0.35	0.07	0.27	0.28	0.01
Case 4	0.15	0.14	0.01	0.38	0.43	0.16	0.31	0.31	0.07
Case 5	0.46	0.42	0.10	0.46	0.42	0.05	0.27	0.37	0.06

Case 6	0.29	0.32	0.04	0.20	0.20	0.00	0.22	0.18	0.00
Case 7	0.12	0.12	0.01	0.44	0.45	0.08	0.38	0.36	0.04
Case 8	0.09	0.11	0.01	0.28	0.34	0.02	0.36	0.20	0.03
Case 9	0.21	0.21	0.02	0.35	0.34	0.01	0.30	0.25	0.01
Case 10	0.20	0.21	0.03	0.42	0.42	0.03	0.33	0.37	0.03
Case 11	0.20	0.13	0.02	0.37	0.34	0.02	0.26	0.14	0.02
Case 12	0.24	0.20	0.02	0.22	0.21	0.02	0.30	0.30	0.03
Case 13	0.27	0.17	0.01	0.32	0.34	0.02	0.17	0.28	0.02
Case 14	0.25	0.22	0.01	0.40	0.33	0.11	0.35	0.28	0.01
Case 15	0.33	0.26	0.03	0.29	0.31	0.08	0.50	0.49	0.06
Average	0.294667	0.266667	0.070667	0.377333	0.404667	0.098667	0.312667	0.306	0.029333

醫師評估 GPT 結果的評分及評語

	原始醫療報告	我們的 GPT 生成	MiniGPT1522 生成
Case 1	Parathyroid gland: There is a hypoechoic mass, about 1.6x0.7cm, in the posterior aspect of Lt thyroid, with heterogeneous content. Impression: Lt side, one parathyroid mass.	Parathyroid gland: Left parathyroid area: There is a hypoechoic mass, about 1.6x0.7 cm, in the posterior aspect, with heterogeneous content. Impression: One left parathyroid mass.	Parathyroid gland: The hypoechoic mass, 1.6x0.7 cm, in the posterior aspect of Lt thyroid, with heterogeneous content. Impression: Lt side, one parathyroid mass.
	醫師評價(分數+評語)	85 準確，自然，無贅字	82.5 語言稍嫌不夠自然，可接受的準確度
Case 2	Parathyroid gland: There is a hypoechoic mass, 0.7x0.3cm, in the posterior aspect of Rt thyroid, with homogeneous content. Impression: Rt side, one parathyroid mass.	Parathyroid gland: Right parathyroid area: There is a hypoechoic mass, about 0.7x0.3 cm, in the posterior aspect, with homogeneous content. Impression: One right parathyroid mass.	Parathyroid gland: A hypoechoic, well-defined, 0.7x0.3cm mass delete (with a low echogenicity content) is noted in the lateral thyroid bed. Impression: One right lateral parathyroid mass.
	醫師評價(分數+評語)	82.5 完整，一軸的長度差異較大	74 報告語言自然流暢接近口語，但兩軸之量測尺寸差異較大
Case 3	Parathyroid gland: Right parathyroid area:	Parathyroid gland: A hypoechoic mass (1.32 cm), situated lateral to	0.89mm, 1 person with a hypoechoic mass in the right neck with

	<p>Upper: hypoechoic mass with homogeneous content in the posterior aspect 1.32x 0.96x0.58cm No typical vascular supply sign</p> <p>Lower: No mass</p> <p>Impression: Right upper parathyroid mass</p>	<p>the low pole of right thyroid, with homogeneous content. Impression: Mass of right parathyroid adenoma.</p>	<p>homogenous to delete(isovascular pattern (mimicking parathyroid gland?)). Impression: Parathyroid swelling, one cystic lesion (1.32 cm) delete (rGO) isovascular pattern). Delete (No parathyroid enlargement was noted. A thyroid scan demonstrated a 1.2x1.08cm)hypoechoic mass in the right upper thyroid border. A thyroid US suggested hyperparathyroidism as well. A total thyroidectomy was performed.)</p>
	醫師評價(分數+評語)	70 Mass of left thyroid adenoma 不是一個標準的描述方式，位置不正確，但測量尺寸準確	42.5 有推斷的報告內容，對於 cystic lesion 的描述不正確，報告有前後矛盾之處，但盡可能提供訊息對打報告的醫師是優點，因為可以針對其提供之訊息做修正。最後一句 A total thyroidectomy was performed.不知所云
Case 4	<p>Parathyroid gland: Left parathyroid area: One hypoechoic mass with homogeneous content in the posterior aspect 1.52x0.84 cm. Impression: One left parathyroid mass, including one with</p>	<p>Parathyroid Gland: A hypoechoic mass, with homogeneous content of 1.52x0.84 cm, is appreciable, posterior to left lower thyroid, with intermediate vascularity. This lesion appears to be a parathyroid adenoma.</p>	<p>Renal ultrasound of posterior compartment of left kidney delete (with micro-cystic structures,) and hypoechoic to mid-lobe thyroid tissue homologies are seen. Impression: 1 heterogeneous, isoechogenic nodule in left upper portion delete and 2 cystic Renal mass of left lobe show nodularity in</p>

	partial calcification.		exact portion (8.3 x 5.7 cm) with moderate amount of hyperechogenicity. Impression: 1 Compete with slight extra-renal supratentorial blood flow.
醫師評價(分數+評語)		95 流暢正確的描述	35 目標組織並不是腎臟，此報告提供了錯誤的訊息
Case 5	Parathyroid gland: Right parathyroid area: 1 hypoechoic mass with homogeneous content in the posterior aspect 1.14x0.54 cm Impression: One right parathyroid mass	Parathyroid gland: A small hypoechoic mass (1.14 x 0.54 cm) is noted in the right parathyroid floor near isthmus with multiple echoes. Impression: Right side, a small heterogenous mass.	Parathyroid gland is wrong (marked hypoechoic mass, 1.5x0.6cm, in the posterior aspect of Lt thyroid.) The echo pattern is heterogeneous, mass-like nodule with peripheral low blood flow. Impression: Solitary parathyroid mass, possible right low neck mass.
醫師評價(分數+評語)		87.5 很棒，可以判斷出接近 isthmus，結論正確，是可以直接使用的報告	50 大致正確但文法怪且有奇怪贅字
Case 6	PARATHYROID ECHO Echo: A enlarged parathyroid gland: LL: 1.24x0.86x0.67 cm Diagnosis: One parathyroid galnd mass. Suggest: May correlate with Parathyroid scan.	Parathyroid: There is one mass found in left area, which is about 1.24x0.8cm in size with iso to hypoechoic heterogeneous in echo distribution. The lesion is with complete Halo. The remaining part of thyroid show heterogeneous hypoechoic pattern. Impression: Left mass, r/o parathyroid enlargement.	1.02:1.16 cm: L-parathyroid gland . Diagnosis: One hypoactive parathyroid gland is suspected .Suggest: Follow-up: 1-3 months.
醫師評價(分數+評語)		92.5 文字自然流暢，但 the lesion is with complete Halo 不太正	57.5 怪異的簡潔，也有奇怪的臨床建議，是否為 Hypoactive 也無法如此判

		確。整體報告品質可接受。	斷
Case 7	<p>PARATHYROID ECHO</p> <p>Echo:</p> <p>A large heterogeneous hypoechoic lesion</p> <p>N1:</p> <p>2.86x2.12x2.01cm is found in left middle to lower lobe. This lesion may be thyroid nodule or parathyroid adenoma.</p> <p>Diagnosis:</p> <p>suspect left lobe thyroid nodule or parathyroid adenoma</p> <p>Suggest:</p> <p>please correlate with parathyroid scan</p>	<p>PARATHYROID GLAND :</p> <p>Upper: 2.69x2.73cm; Hypoechoic; Heterogeneousomeganoiod Lesion is found in left lobe of thyroid gland</p> <p>Suggestion: left parathyroid adenoma or hyperplasia.</p>	<p>1.07-1.08x0.92cm: left upper neck(L), L lower neck (R) with low echogenecity. Parathyroid gland enlargement? Wrong (Diagnosis: Cushing's disease?)</p>
醫師評價(分數+評語)		80 有自己發明的怪異單字與錯字，判斷位置正確，型態正確。	40 尺寸判斷錯誤，診斷不知從何而來。Cushing's disease 無法這樣下診斷。
Case 8	<p>PARATHYROID ECHO</p> <p>Echo:</p> <p>A nodule with size of 2.3x1.6x1.2cm was shown heterogeneous hypoechogenicity at low pole of left lobe of thyroid. The remaining thyroid tissue was normal echo pattern.</p> <p>Diagnosis:</p>	<p>Parathyroid gland:</p> <p>An regular well-defined nodule, 2.3 x 1.2 cm, in the posterior aspect of the left thyroid, with heterogeneous echoes. Faint peripheral vascular pattern noted.</p> <p>Impression: Possible parathyroid adenoma left.</p>	<p>1.06 cm in depth and 1.27 cm in width or 2.13 cm in length. PARATHYROID C-SI</p> <p>Suggest to go to thyroid clinic for a wrong (parathyroid cyst, suspect a phe-nephritis, and show thyroid) uptake scan.</p>

	compatible with parathyroid gland enlargement(Left lower) Suggest: Surgical treatment		
醫師評價(分數+評語)		85 尺寸正確，文字流暢，型態判斷正確。但最後的 left 不應該放在那個位置。	35 不知所云
Case 9	PARATHYROID ECHO Echo: The palpable lesion (PA) in left thyroid is about 1.5 x 1.2 x 0.6 cm in size, which is hypo echo homogeneous in echo distribution.The remaining part of thyroid show homogeneous iso echo pattern. Diagnosis: One parathyroid mass Suggest: Parathyroid scan. Ca, iPTH	Echo: Left lobe: In the upper lobe, one hypoecho homogeneous mass (1.5x0.6cm) with incomplete halo and delete (cystic contents) is detected in the lateral side.Impression: Parathyroid adenoma in the left upper thyroid bed	(1.15 cm x 0.94 cm in longest-lower -posterior aspect. Parathyroid enlarged. Diagnosis: PCC, thyroid mass.) → not well written
醫師評價(分數+評語)		85 完整，流暢，正確	50 描述文句跟診斷沒有邏輯，也不相符
Case 10	PARATHYROID ECHO Echo: The palpable lesion (P) in right thyroid is about 1.0 x 0.8 x 0.5 cm in size, which is hypo echo homogeneous in	Echo: There is a isoecho to hyperecho mass, about 1.0x0.5cm, in the posterior aspect of right thyroid, with homogeneous content.Impression: Right side, one large	1.0 cm x 1.1 cm x 1.2 cm in size, fusiform lesion at lateral portion of right lobe of thyroid with heterogeneous hypoenhanced blood vessel and some calcification. The image show a mass-like lesion

	<p>echo distribution. The remaining part of thyroid show homogeneous iso echo pattern Diagnosis: parathyroid mass Suggest: Parathyroid scan.</p>	parathyroid mass.	<p>with moderate heterogenous and homogeneous low signal in delete (iso-trophic level with moderate extra-nodular extrathyroidal reactive lesion at extra-thyroid level). Delete (This lesion could be surgical treatment. Corticosteroid injection was given recently in that area.) right thyroid mass was noted.</p>
醫師評價(分數+評語)		87.5 完整，正確，流暢	50 大致上描述是正確的，但怎麼處理增加太多腦補的內容了
Case 11	<p>PARATHYROID ECHO Echo: There is 1 hypoechoic nodule near right thyroid middle lobe (N1: 10.7 x 6.6 x 6.1 mm) , suggestive of enlarged parathyroid glands. Right thyroid is homogeneous isoechogenicity. Diagnosis: One nodule near right thyroid, compatible with enlarged parathyroid gland Suggest: Please correlate with parathyroid scan</p>	<p>Parathyroid: Right lobe: There is one hypoechoic heterogeneous nodule(1.05x0.6cm) at lower portion.Impression: Right low parathyroid adenoma</p>	<p>One hypoechoic mass at left posterior aspect of thyroid (1.70 x 0.64 cm) (b) R: 0.52 x 0.47 cm with heterogeneous and less defined hypoechoic mass, showing a partially calcified nodule in its mediolateral area. The thyroid echo showed no central necrosis.Diagnosis: wrong (cystic adenoma of thyroid) suggest cystic lesion of thyroid gland. Suggest further follow-up.</p>
醫師評價(分數+評語)		75 正確，流暢，可用的報告	60 大致正確但有流暢性問題跟錯誤單字。

Case 12	<p>PARATHYROID ECHO</p> <p>Echo:</p> <p>A hypoechoic nodule over lower pole of left lobe. A nodule with partial calcified rim (N1: 16.7 x 13.8 x 8.3 mm) located over the lower part of left lobe. Parathyroid gland enlargement is most likely.</p> <p>Diagnosis:</p> <p>Left lower thyroid hypoechoic nodule, favor parathyroid enlargement or a cystic change</p> <p>Suggest:</p> <p>May correlate with parathyroid scan. May perform echo-guided aspiration if tenderness over left lower thyroid is persistent. May correlate with thyroid autoantibody.</p>	<p>Echo of left nodule with hypoechoic homogeneous content about 1.67x1.4cm.</p> <p>Impression: Suspicious for malignant nodule. Suggest follow up in 12 months.</p>	<p>One hypoechoic nodule in the thyroid lobe is found, about 1.32 x 1.24 x 0.79 cm in size, and homogeneous in texture. There is no fibrinous core and mildly cystic lesion with no mass effect. No calcification is found. Around the lesion there is slight posterior extension. Diagnosis: HPTH/SCC of left thyroid lobe, Left thyroid lobe. Suggest: Additional correlation with ultrasonic diagnosis</p>
醫師評價(分數+評語)		65 對於病灶的描述稍嫌單薄，大致正確	70 描述正確，報告未建議也合理。
Case 13	<p>PARATHYROID ECHO</p> <p>Echo:</p> <p>Left:</p> <p>A nodule with heterogeneous hypoechoic density and complete halo, located in left low</p>	<p>Echo:</p> <p>Left lobe: In the upper lobe, one hypoechoic heterogeneous nodule(0.63x0.5cm) with incomplete halo and delete (cystic contents) is detected in the lateral side. Impression:</p>	<p>1.07cm in size, heterogeneous lesion suspected hypoechoic mass with high vascularity (1.19 x 1.32 x 0.85 cm) was found in left thyroid bed (PE: 16/60). Wrong → A large low echo nodule was observed in the</p>

	<p>thyroid, is about 0.61 x 0.44 x 0.53 cm in size (calcification: nil; blood flow: no increase blood flow).</p> <p>Diagnosis: Left hypoechoic lesion, r/o parathyroid lesion</p> <p>Suggest: Correlate with iPTH and serum Ca, or arrange parathyroid scan.</p>	<p>Parathyroid adenoma in the left thyroid bed</p>	<p>same posterior portion of cavity and mixed content with surrounding parenchymal inflammatory cells suggest possible malignancy. The lesion may be from left superior thyroid artery infarction. With additional adjacent liver lesions are suspected to be hyperthyroidism. Left middle to low echo levels below the detection level of sonography (PE:12.94 cm). No FDG-PET was done, and SRS is suspicious. Right upper abdomen CT was suggested for this area. Suggest a follow up ultrasound, MRI or dynamic scan of this region.?</p>
醫師評價(分數+評語)		85 流暢，大致正確，文字自然	32.5 報告中混雜組織學用語，尺寸描述也不正確，出現其他器官，建議的方向也很詭異。
Case 14	<p>PARATHYROID ECHO</p> <p>Echo: L't: An impalpable nodule in left middle lobe is 2.13 x 1.34 x 1.02 cm with hypoechoic, heterogeneous in echo distribution with intranodular hypervascularity.</p> <p>Diagnosis: Parathyroid</p>	<p>Parathyroid: There is one nodule found in left area, which is about 2.1x1.46cm in size with hypoechoic heterogeneous in echo distribution. The lesion is with complete Halo. The remaining part of thyroid show heterogeneous hypoechoic pattern. Impression: Left nodule, r/o parathyroid enlargement.</p>	<p>*LU (left upper) lobe and delete LN (left nodular) hypoechoic lesion) in the left inferior parathyroid gland are observed. Delete→The inferior parathyroid gland is hypoechoic, measured as 1.290.560.69 cm. delete→Left lower thyroid lobe has a heterogeneous low echoic nodule which is 1.080.870.66 cm. left middle thyroid lobe has a</p>

	adenoma Suggest: May arrange parathyroid scan		low echoic nodule which is 0.720.63*0.54 cm. Right upper thyroid lobe is normal. Suggest: ?
	醫師評價(分數+評語)	90 大致正確的描述，只需少量修改即可發報告	35 錯誤的尺寸，雜亂的文句，無法使用的報告
Case 15	PARATHYROID ECHO Echo: L't: A hypoechoic, impalpable nodule in left middle extrathyroid lobe is 1.05 x0.95 x 0.94 cm with heterogeneous in echo distribution without hypervascularity. Diagnosis: Parathyroid Hyperplasia Suggest: Arrange parathyroid scan for correlate with clinical finding	PARATHYROID ECHO Echo: Lt thyroid bed: hypoehogenic heterogeneous . Lt lobe show a nodular echogenic, hypo-echogenic nodular lesion. Diagnosis: Parathyroid adenoma, L't lobe suspected.	one small hypoechoic mass is noted in the left wrong → upper lung (LU) thyroid with a minimal extrathyroid extension and heterogeneous in echogenicity. Delete → No parathyroid enlargement is noted. Wrong → Renal scan showed a small S Cl size 0.6 x 0.4 x 0.5 cm, isoechogenic in echo distribution, with homogenous and heterogeneous echo pattern in the central portion. The remaining thyroid lobe is normal.
	醫師評價(分數+評語)	77.5 iso-venous 不知何義，可以修得更流暢一些。	25 不是腎臟也不是肺部組織，報告前後矛盾，無法使用。
	平均分數	82.83	49.27

結論

本論文提出了 UltraPTGPT，一種結合物件偵測與大型語言模型的方法，用於檢測超音波影像的副甲狀腺病灶並生成醫療報告。在位置記號圖示辨識和病灶辨識分類方面，本研究使用了 YOLOv7 並加上資料清理、篩選和擴增的處理後，透過上述方法能夠讓模型對於 nodule 和 cyst 的準確度能夠上升；在醫療報告的回音性和均質性的判定方面，本研究使用了影像處理技術；在醫療檢查報告生成方面，本研究使用了 Prompt 和 PEFT 的方式，讓 Vicuna 7b 的大型語言模型能夠生成出符合長庚醫院的副甲狀腺超音波檢查的醫療報告格式。提出的方法在位置記號圖示辨識和病灶辨識分類方面分別達到了 99.65% 與 91.04% 的 mAP，相較於其他模型 ViT、YOLOv5 以及 YOLOv7 我們的方法能夠帶來更好的成績。

本研究的方法彌補了在文獻探討中只有針對於影像提供給醫師輔助的不足之處。但是模型也有可能因為超音波影像的雜訊過多或是影像過度模糊而造成誤判，以及在大型語言模型的生成上，由於文字生成機制的原理還是會有低機率出現邏輯不通順，或是描述錯誤的狀況。本研究所提出的方法可以協助臨床放射科醫師更全面性的輔助來判斷副甲狀腺超音波影像，進而提升醫療品質，可以有效的避免因為醫師的精神狀況不佳或是臨床經驗不同等人為因素而產生錯誤。

在未來的研究中，可以通過收集更多且沒有放大和醫師標記的超音波副甲狀腺影像來優化我們的模型性能和驗證模型的泛化性，來協助臨床放射科醫師減少誤判的問題；目前模型僅能針對單一影像進行醫療報告的生成，為了使模型能夠更全面更符合實際應用的情境，未來可以加入讀取同一份檢查的多張影像後將各張針對單一影像的報告統合成一份完整的醫療檢查報告的功能；未來能夠導入 Clip 技術而不再是單獨只用文字描述的 Prompt 以及 RAG 技術來輔助大型語言模型的生成文字準確度以達到減低亂造字或是錯誤拼音的狀況，抑或是嘗試其他微調方式如 LoRA+和其他開源的大型語言模型。