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Synthetic Boost: Leveraging Synthetic Data for Enhanced Vision-Language Segmentation in Echocardiography

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**equal contribution*

Outline

- Echocardiography and Segmentation Models
- Synthetic Data and Prompt Engineering
- Experiments and Results

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Echocardiography

- Cheap, portable and gives HD images
- Requires strong segmentation algorithms

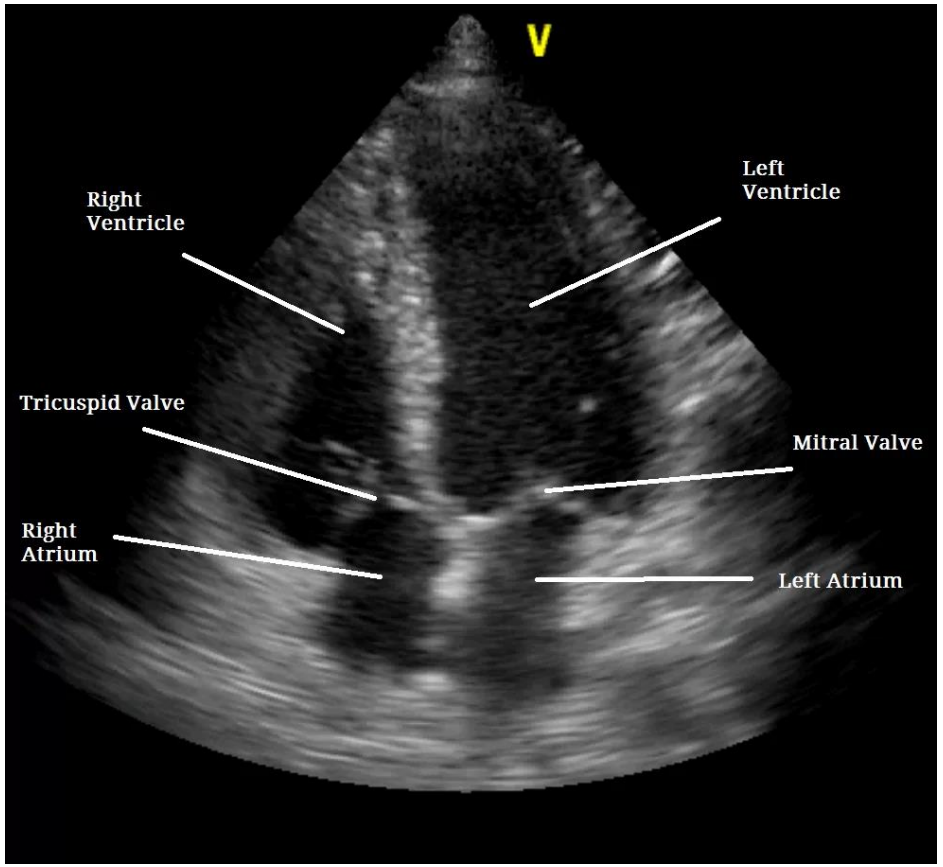


Image source: https://heartsense.in/echocardiogram/

How hard is it to accurately segment different parts in an echocardiography?

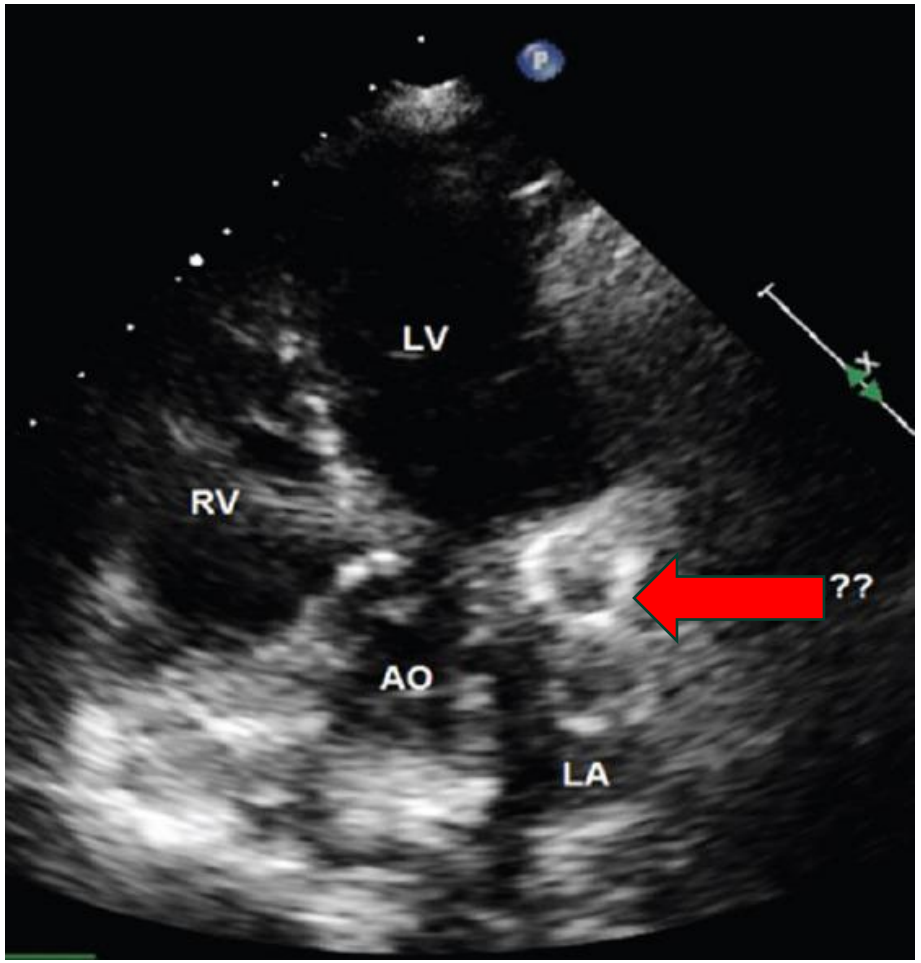
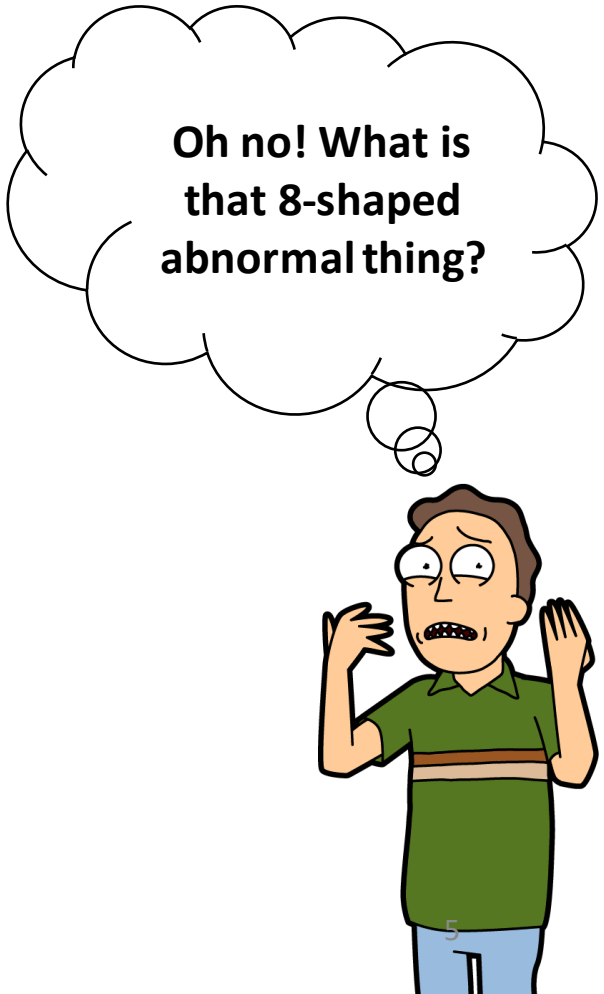


Image source: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7799067/



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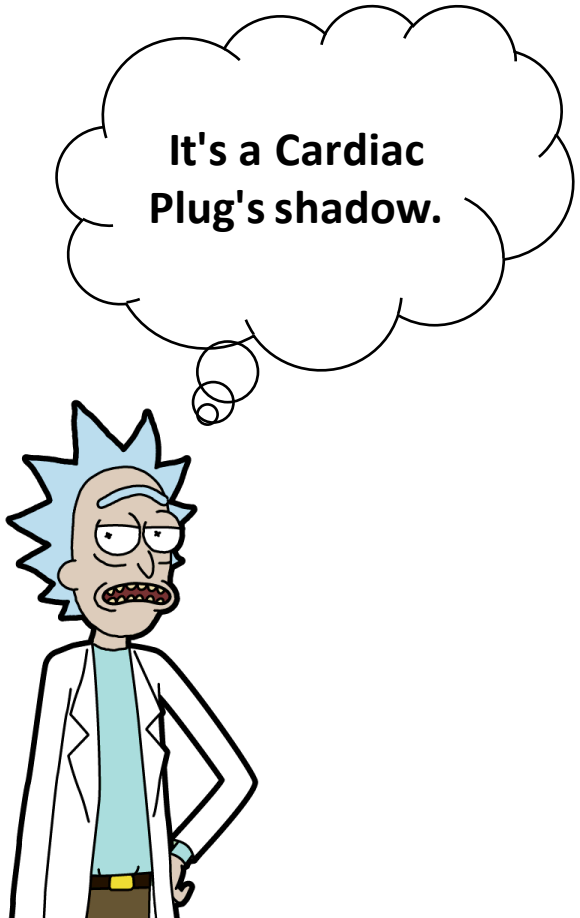

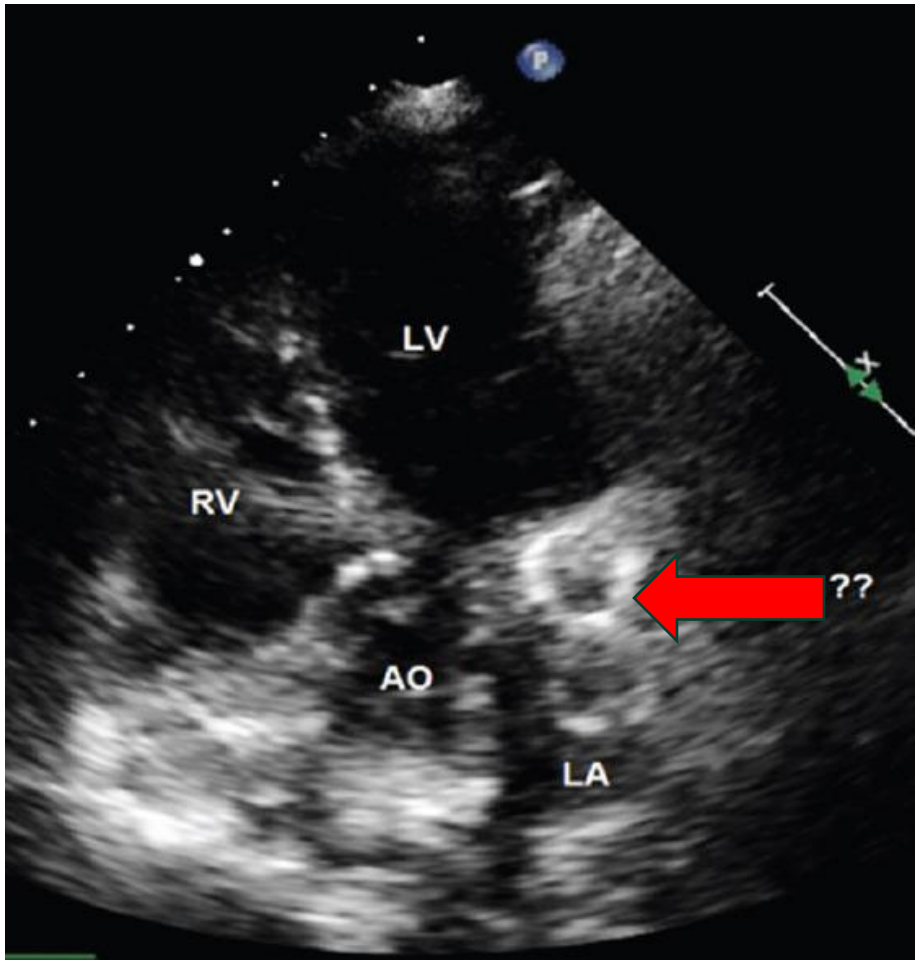

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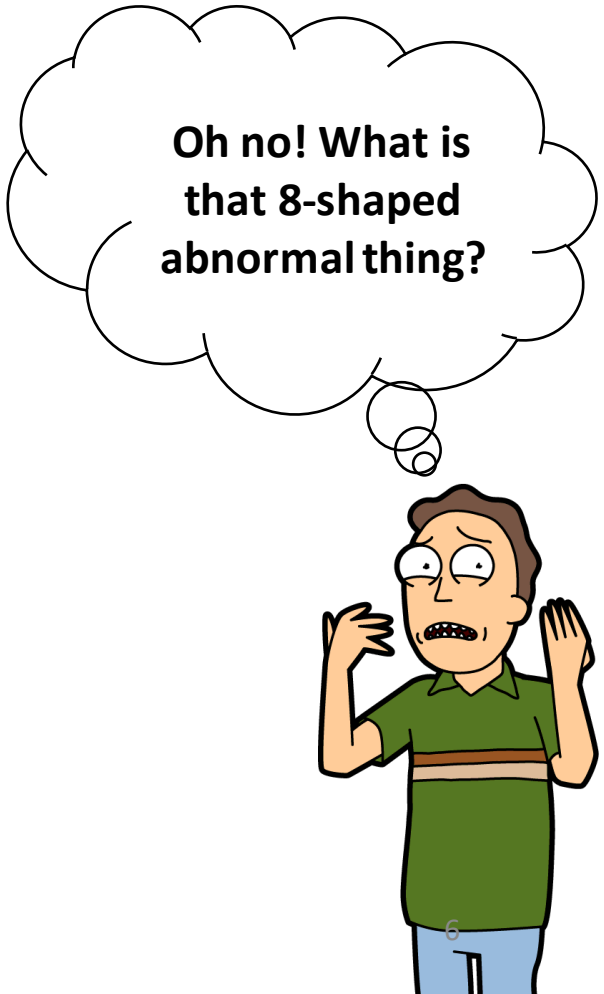
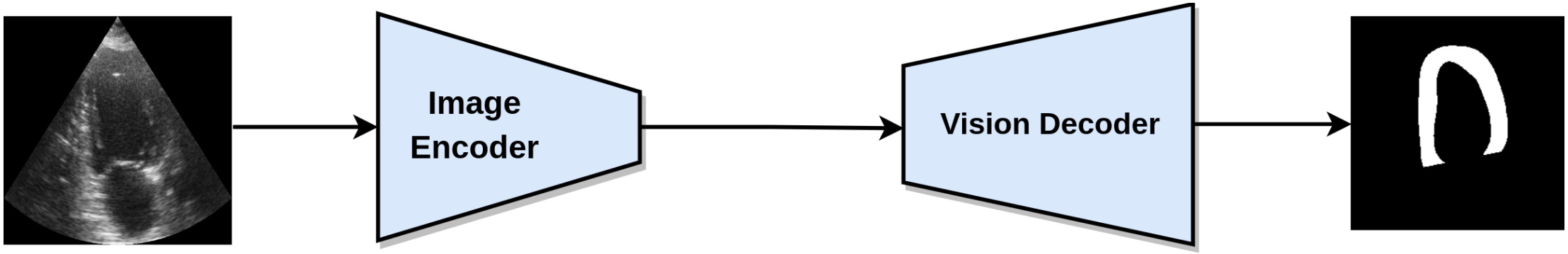


Existing Segmentation Models



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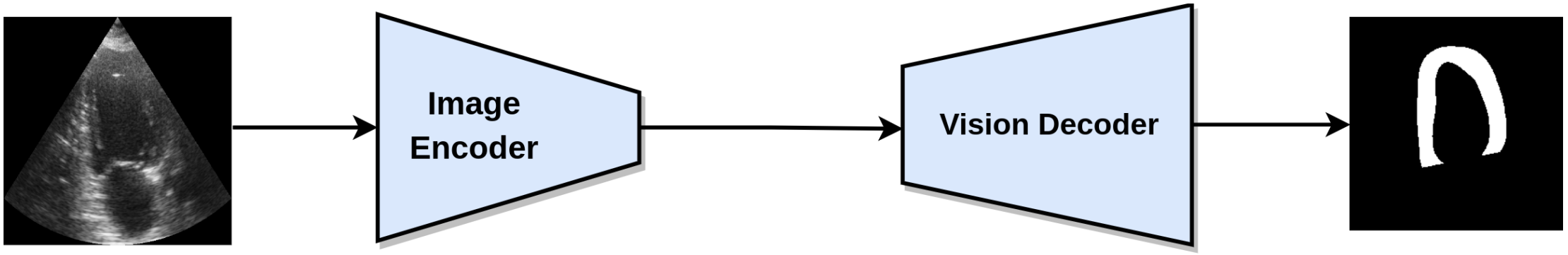
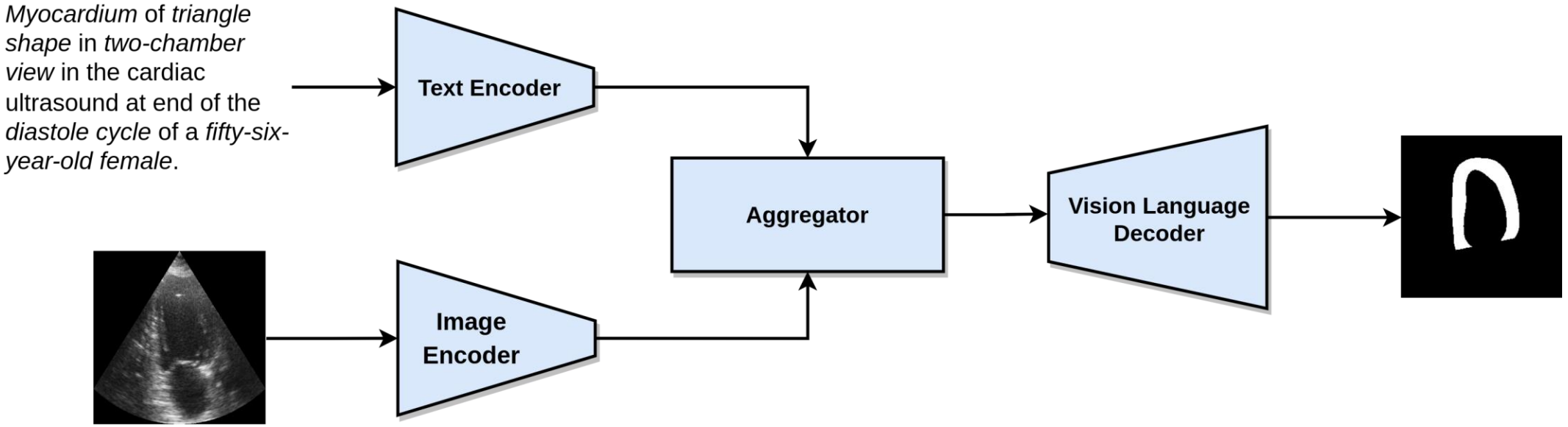
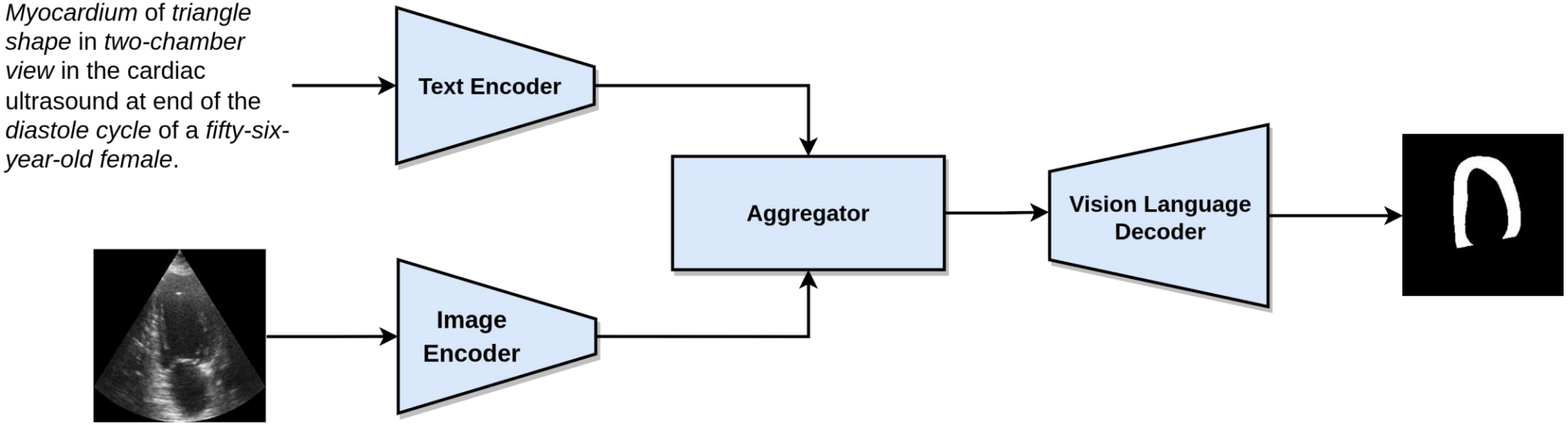


- **Rely on large amount of annotated data for supervised training**
- **Lack explainability**
- **Require retraining when new classes are introduced**
- **Not resilient to distribution shifts**

Vision Language Segmentation Models



Vision Language Segmentation Models



- **Extract rich information from image and language prompt pairs**
- **Aid in accurate and explainable segmentation**
- **Requires large image-prompt pairs for good finetuning performance**

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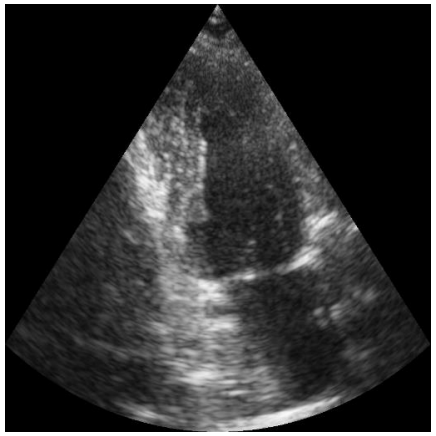
Real and synthetic echocardiography

CAMUS [1]

- Real cardiac segmentation dataset
- 2D apical two-chamber and four-chamber views at end-diastole (ED) and end-systole (ES) cycles
- *Train-val-test split:* 600-400-200

Synthetic Echocardiography [2]

- Synthetic echocardiography images generated using SDMs [3]
- Takes perturbed anatomical masks as conditioning information to denoise the noisy images and generates echocardiographic images
- *Train-val split:* 8000-1000



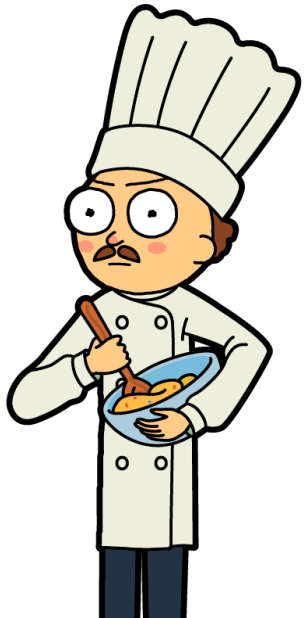
9x more training samples

[1] Leclerc, S., Smistad, E., Pedrosa, J., Østvik, A., Cervenansky, F., Espinosa, F., ... & Bernard, O. (2019). Deep learning for segmentation using an open large-scale dataset in 2D echocardiography. *IEEE transactions on medical imaging, 38*(9), 2198-2210.

[2] Stojanovski, D., Hermida, U., Lamata, P., Beqiri, A., & Gomez, A. (2023). Echo from noise: synthetic ultrasound image generation using diffusion models for real image segmentation. In *International Workshop on Advances in Simplifying Medical Ultrasound* (pp. 34-43). Cham: Springer Nature Switzerland.

[3] Wang, W., Bao, J., Zhou, W., Chen, D., Chen, D., Yuan, L., & Li, H. (2022). Semantic image synthesis via diffusion models. *arXiv preprint arXiv:2207.00050*.

But we don't have prompts for CAMUS. How to get them?



We'll create our own prompts.

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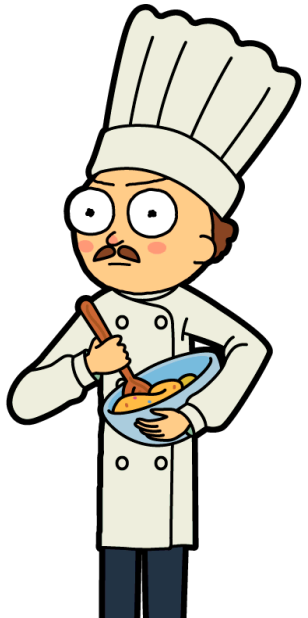
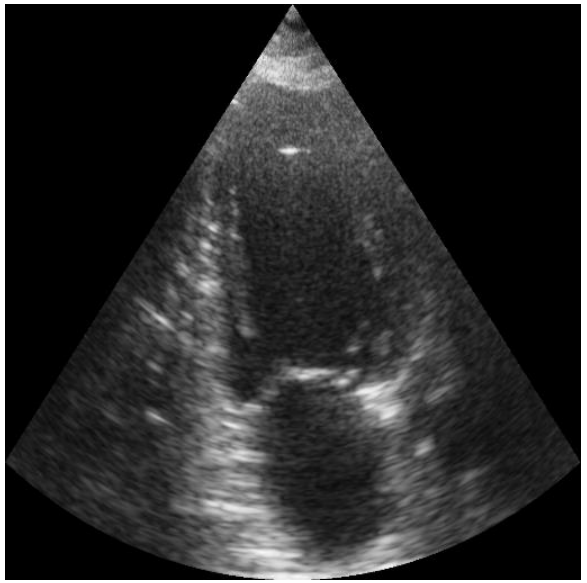


Prompt Engineering

Following our previous work [1], we created 7 different prompts.



Target Structure — Structure's Shape — Apical View

Left ventricular cavity of oval shape in two-chamber view in the cardiac ultrasound at the end of the diastole cycle of a seventy-three-year-old male with good image quality.

Cardiac Cycle — Patient's Age — Patient's Sex — Image Quality

[1] Poudel, K., Dhakal, M., Bhandari, P., Adhikari, R., Thapaliya, S., & Khanal, B. (2023). Exploring transfer learning in medical image segmentation using vision-language models. *arXiv preprint arXiv:2308.07706*.

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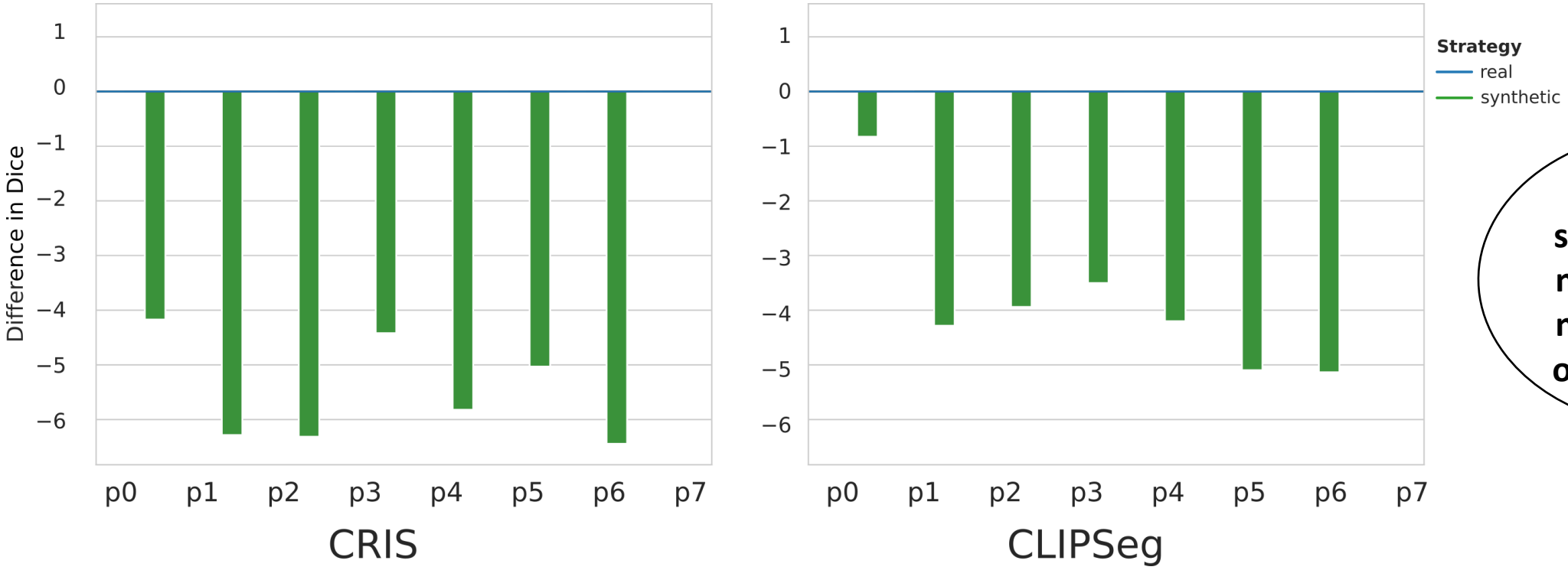
How does synthetic data help in finetuning?



Using just the synthetic data is not helping...we need to look for other strategies.

Synthetic data better than no data.

Quality > Quantity

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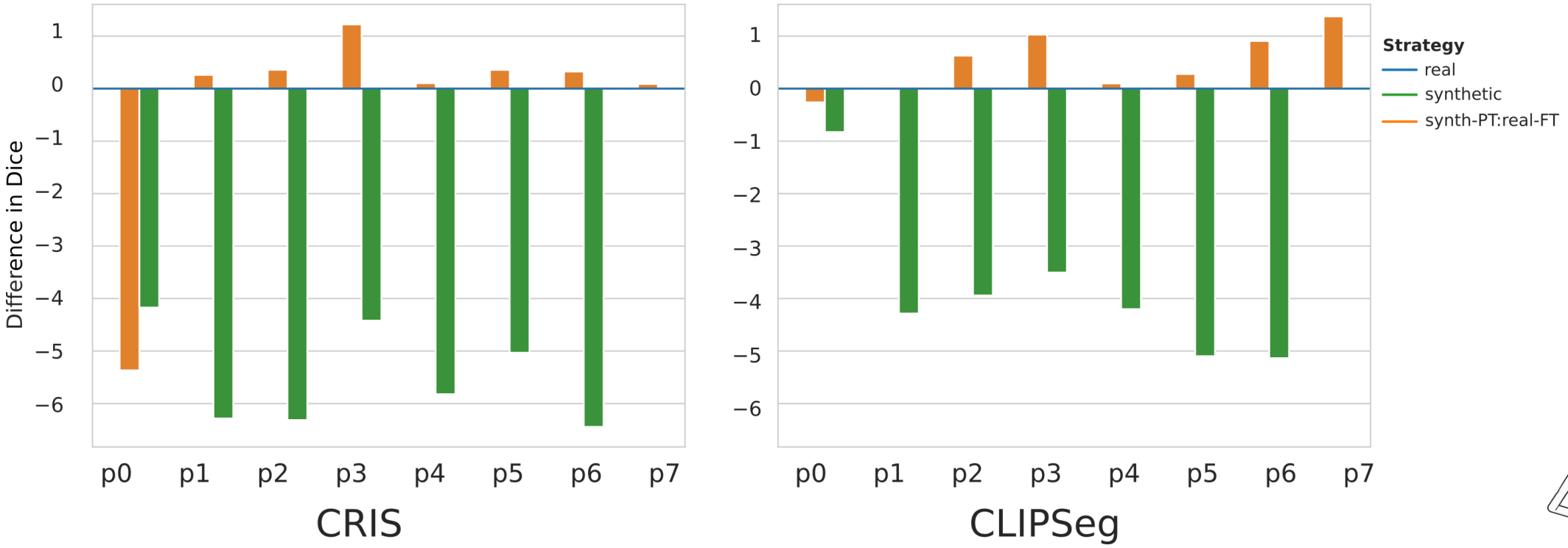
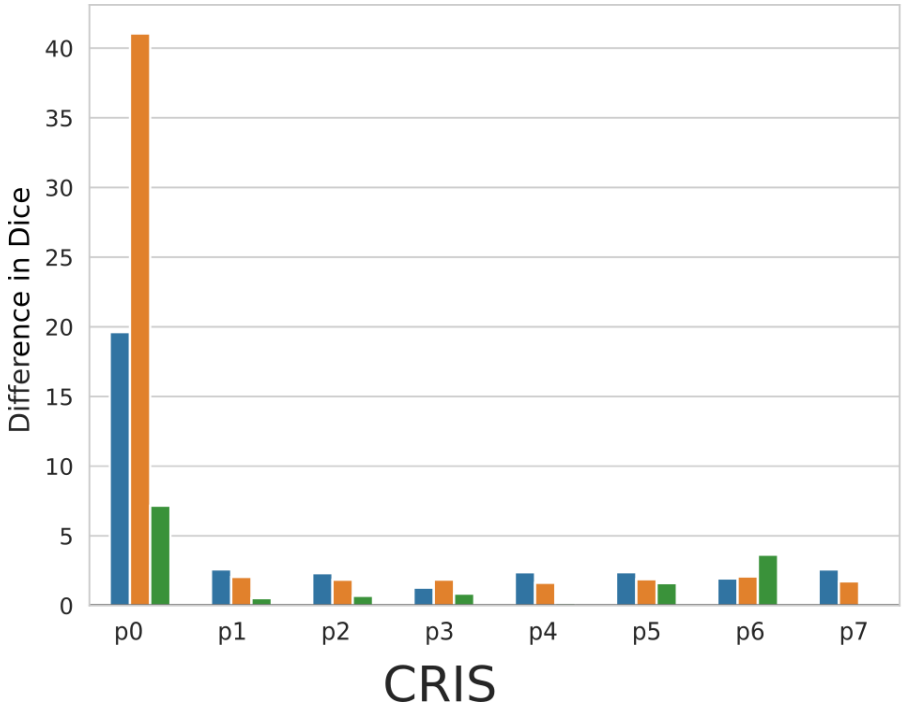
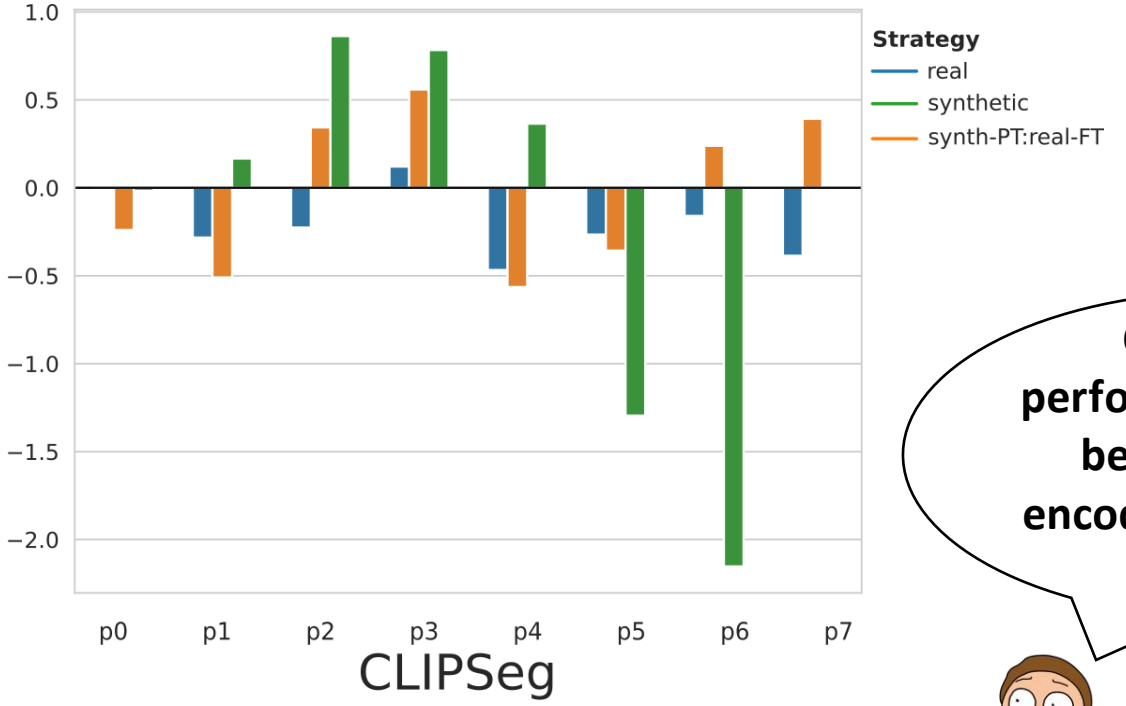


Pretraining on synthetic

Does training the encoders during finetuning give different results?





Only CRIS's performance seem to be better when encoders are trained. But....why?

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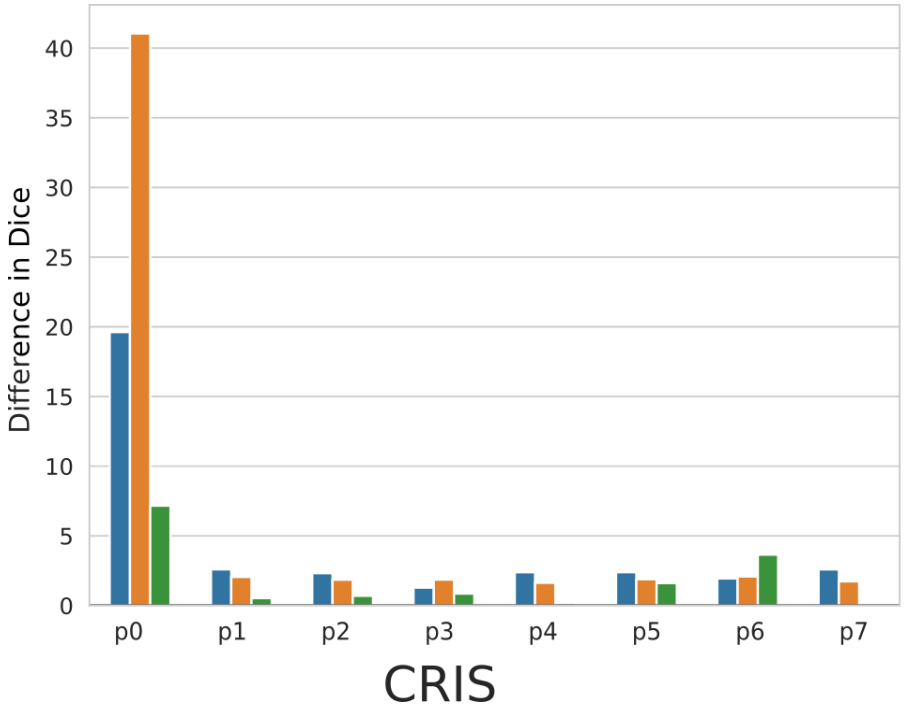

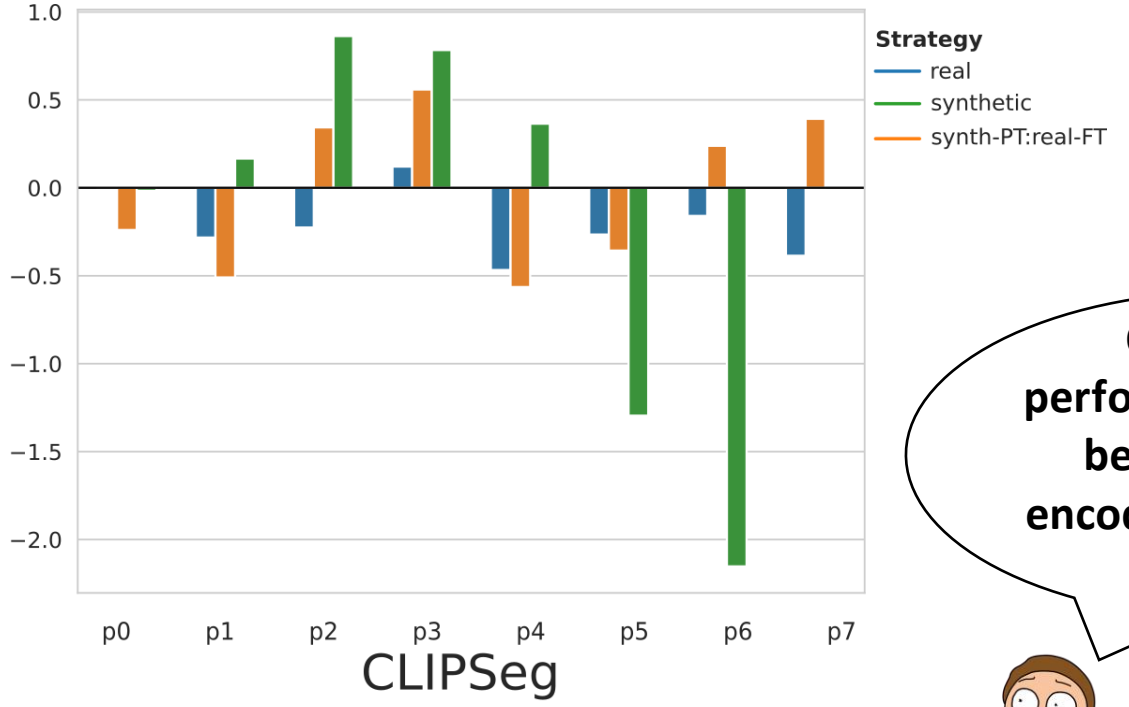

Only CRIS's performance seem to be better when encoders are trained. But....why?

CRIS finetuned encoders 😭

CLIPSeg did not 😢

Future Directions

- Train using both real and synthetic data and describe whether image is real or synthetic in the language prompt.
- Find ways to generate synthetic triplets of image-language-mask at scale without annotated image-mask pairs.

Thank You

Scan this to know more about our work