Medical Intelligence and Robotic Cognition (MIRoC) Lab

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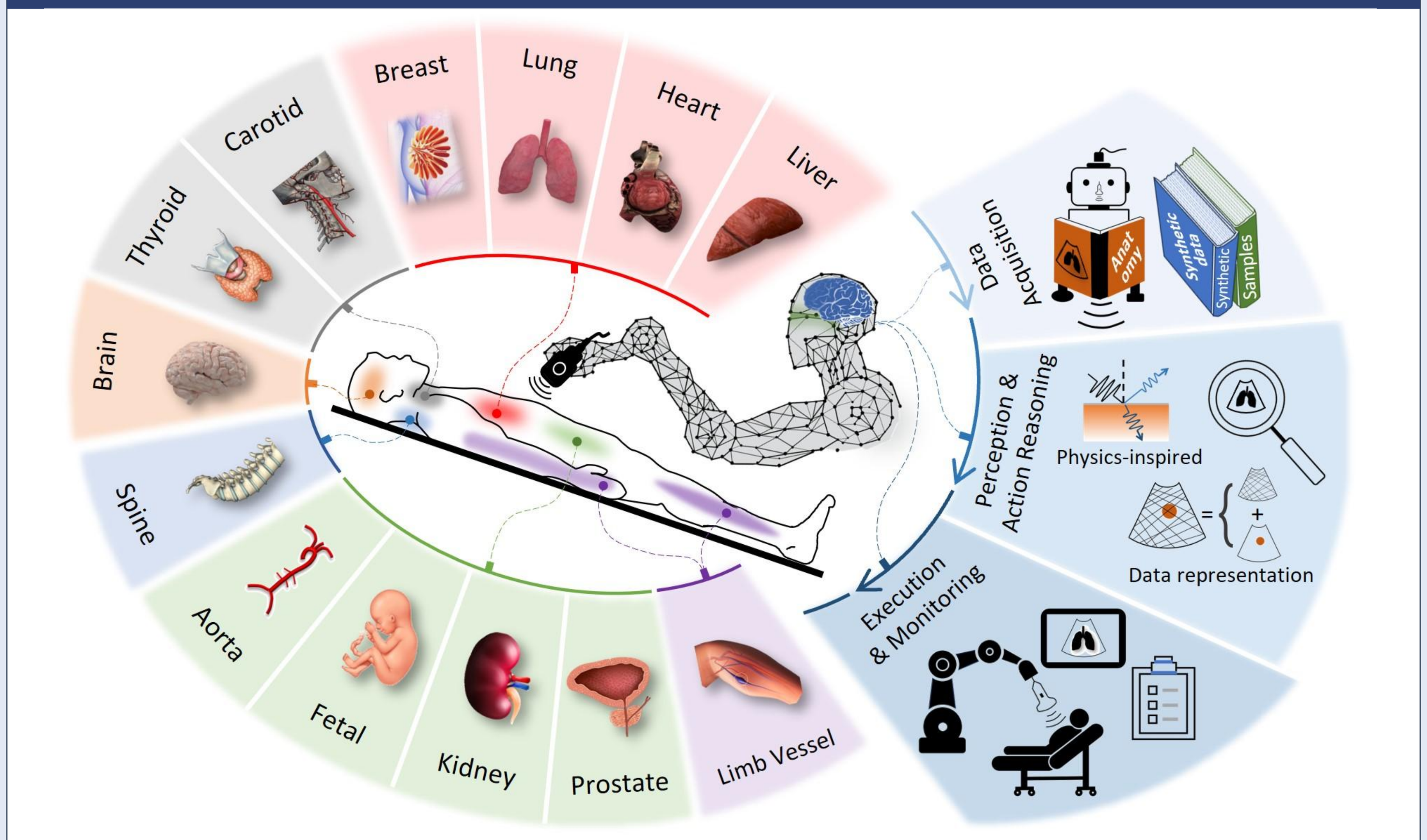
Lab Webpage

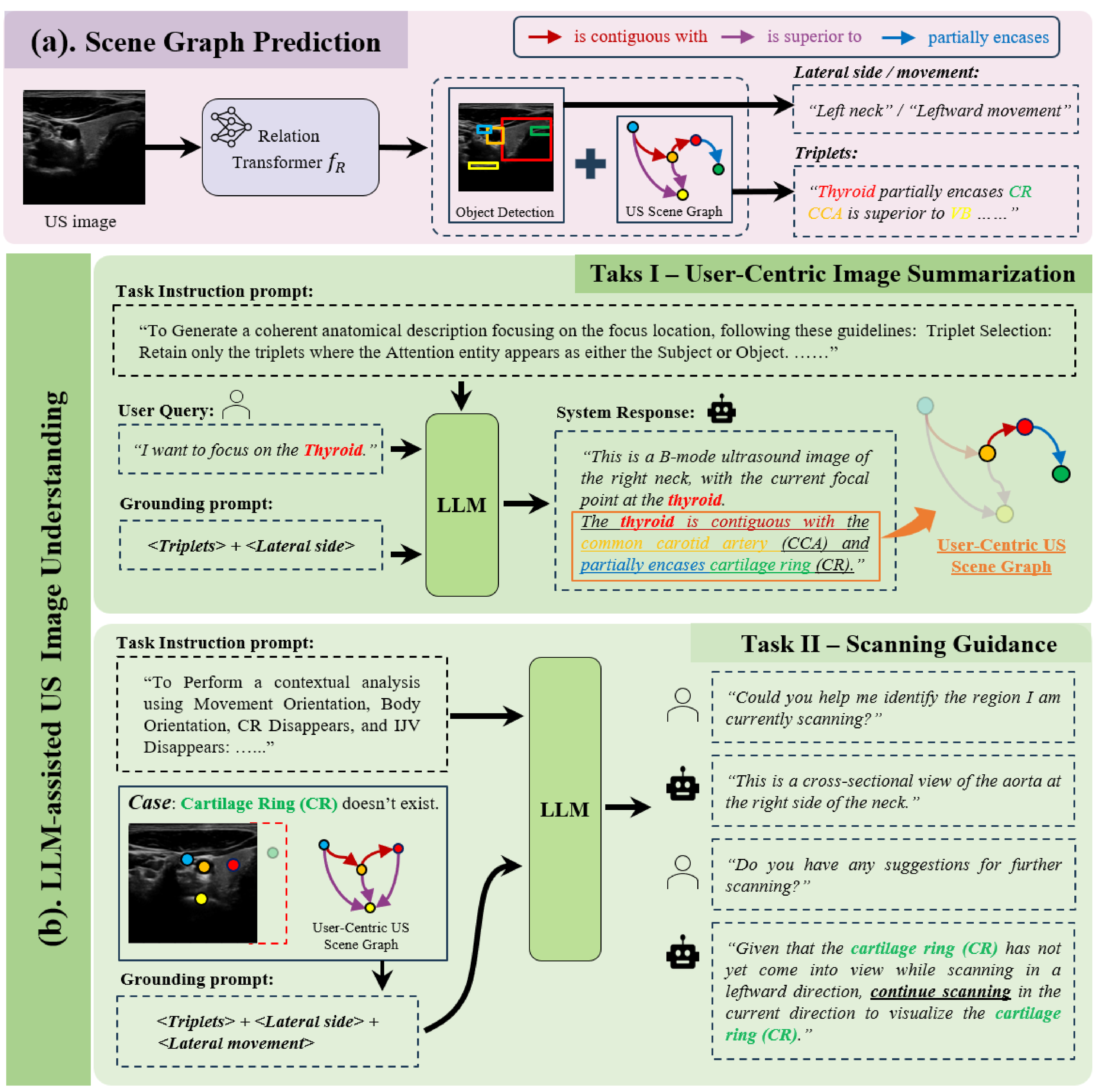
Video Demo

Overview



Y. Bi, Z. Jiang, F. Duelmer, D. Huang, and N. Navab, "Machine learning in robotic ultrasound imaging: Challenges and perspectives." *Annual Review of Control, Robotics, and Autonomous Systems*, 7, 2024

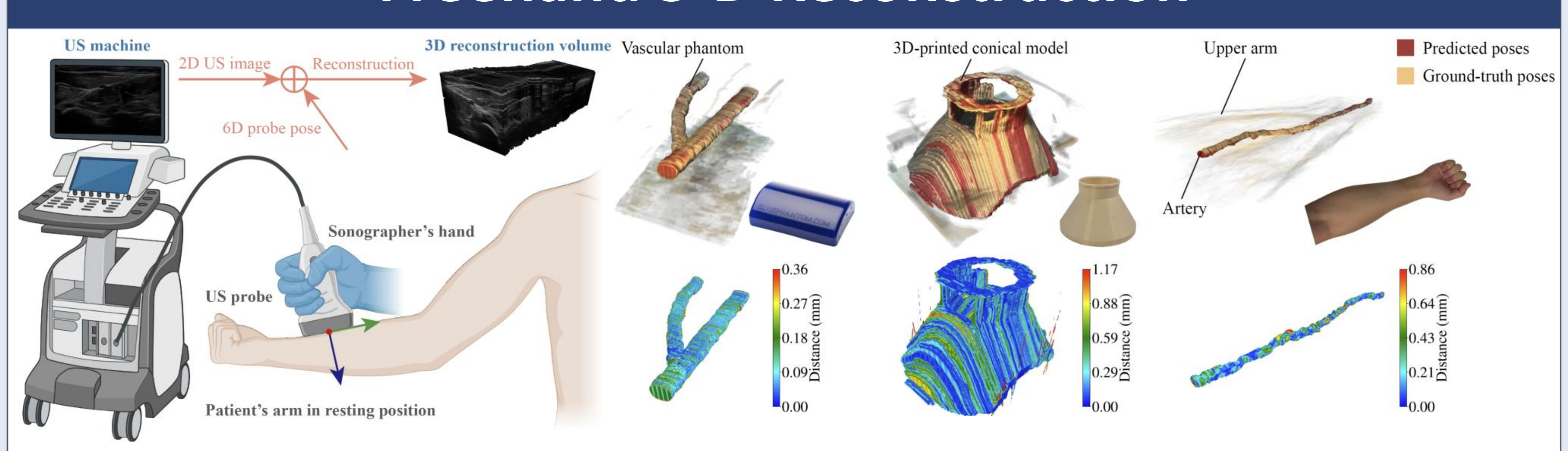
Ultrasound Scanning Guidance and Image Summary



- **SG-based ultrasound explanation:** We leverage highly conceptualized scene graphs (SGs) to generate graspable, user-oriented ultrasound explanations, enabling self-learning of anatomical and physiological knowledge, particularly for POCUS scenarios.
- **LLM-driven scanning guidance:** By integrating SGs with large language models, we provide personalized probe guidance to reveal missing anatomies, representing the first approach to jointly using SGs and LLMs for intuitive ultrasound explanation and scanning guidance.

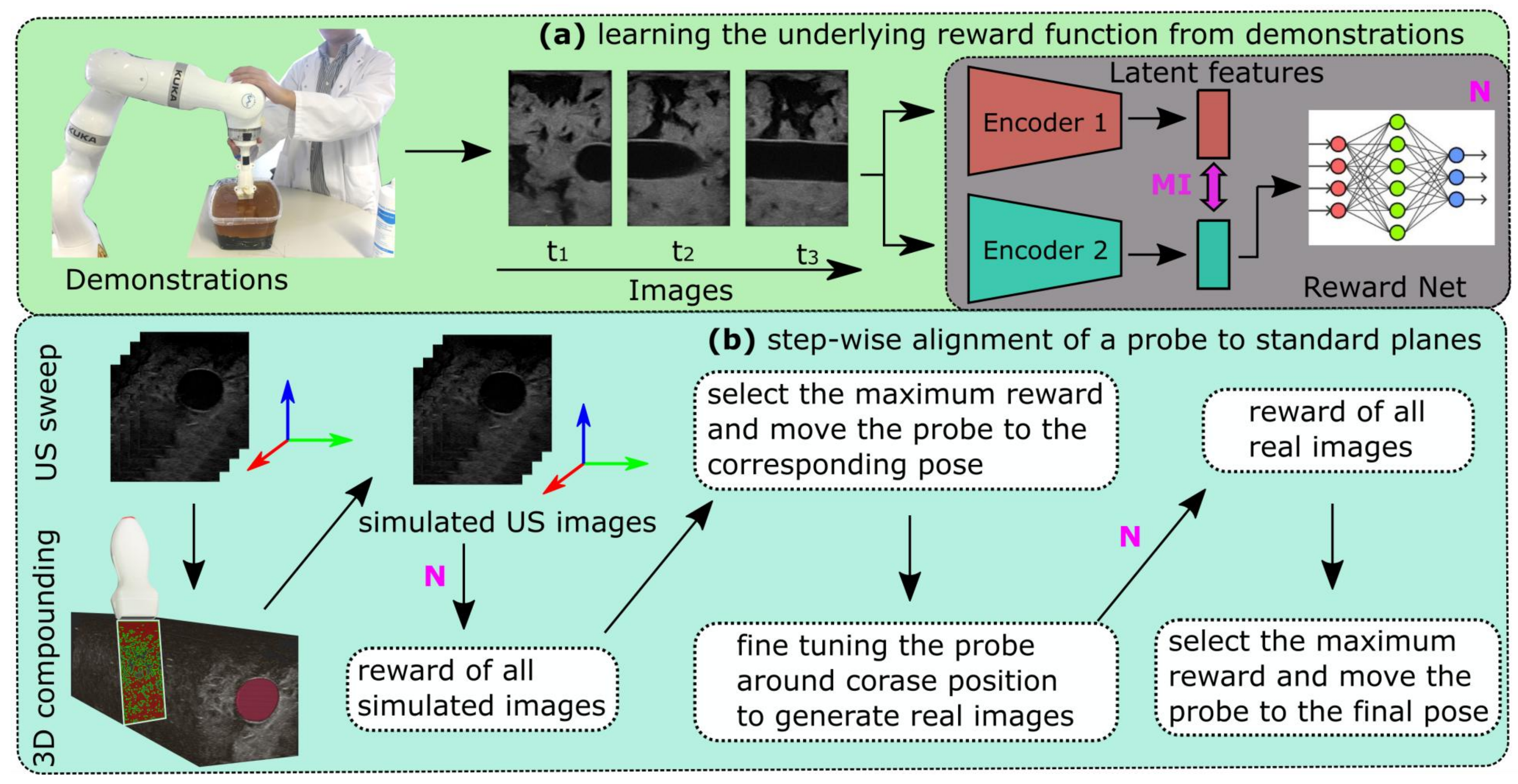
X. Li, D. Huang, Y. Zhang, N. Navab, and Z. Jiang. "Semantic scene graph for ultrasound image explanation and scanning guidance." In ***International Conference on Medical Image Computing and Computer-Assisted Intervention***, pp. 500-510. Cham: Springer Nature Switzerland, 2025.

Freehand 3-D Reconstruction



Y. Zhang, D. Huang, M. Q-H. Meng, N. Navab, and Z. Jiang. "Freehand 3-D Ultrasound Imaging: Sim-in-the-Loop Probe Pose Optimization via Visual Servoing." ***IEEE/ASME Transactions on Mechatronics*** (2025).

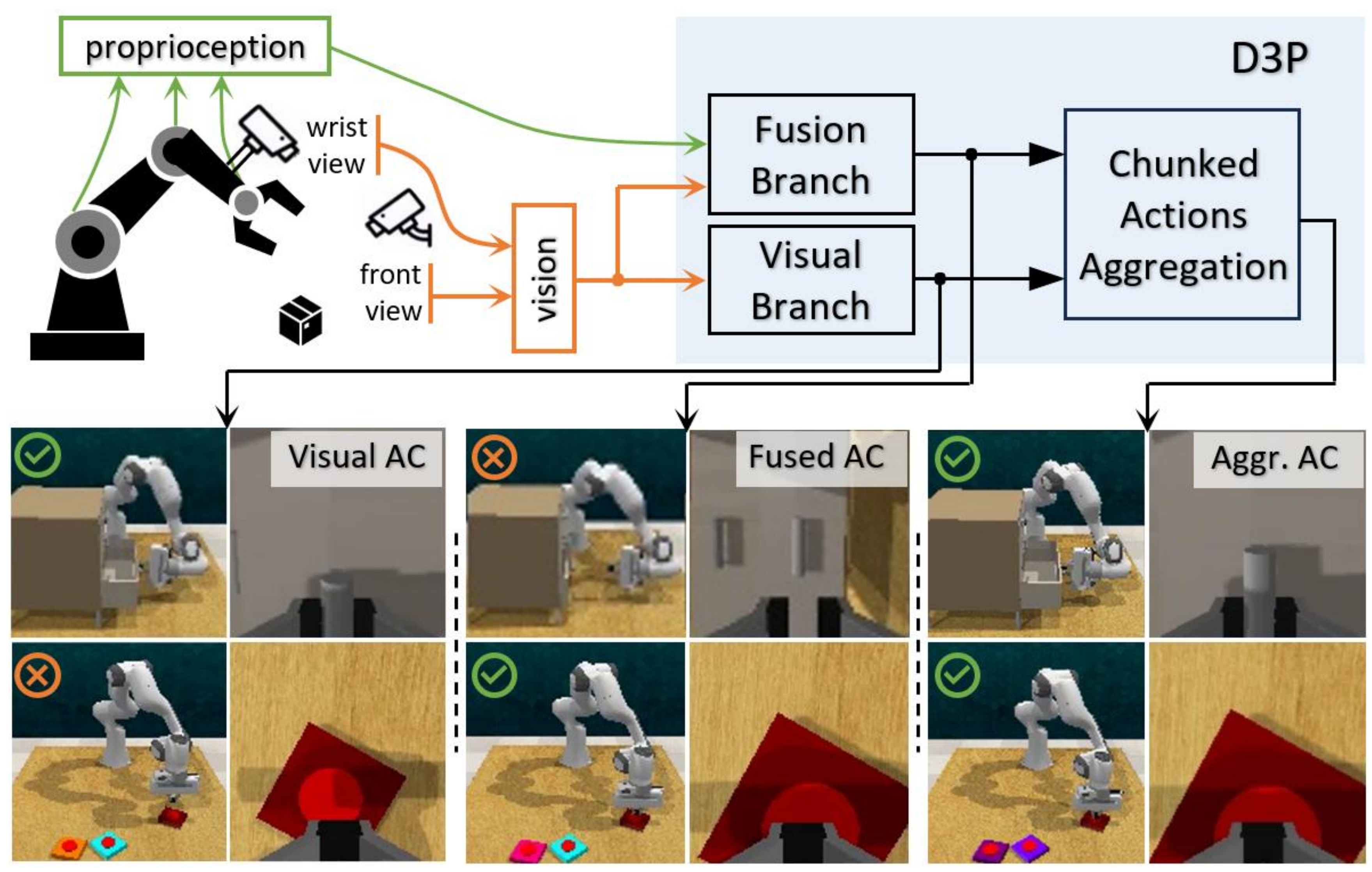
Learning from Demonstration



- **Self-supervised reward learning**: We learn sonographers scanning preferences from a few demonstrations using probabilistic spatial ranking, avoiding manual annotation.
- **Generalizable ultrasound plane navigation**: A GPSR-based framework jointly handles point and line tasks while disentangling task-relevant features to improve generalization to unseen patients.

Z. Jiang, Y. Bi, M. Zhou, Y. Hu, M. Burke, and N. Navab. "Intelligent robotic sonographer: Mutual information-based disentangled reward learning from few demonstrations." ***The International Journal of Robotics Research (IJRR),*** 43, no. 7, pp. 981-1002, 2024.

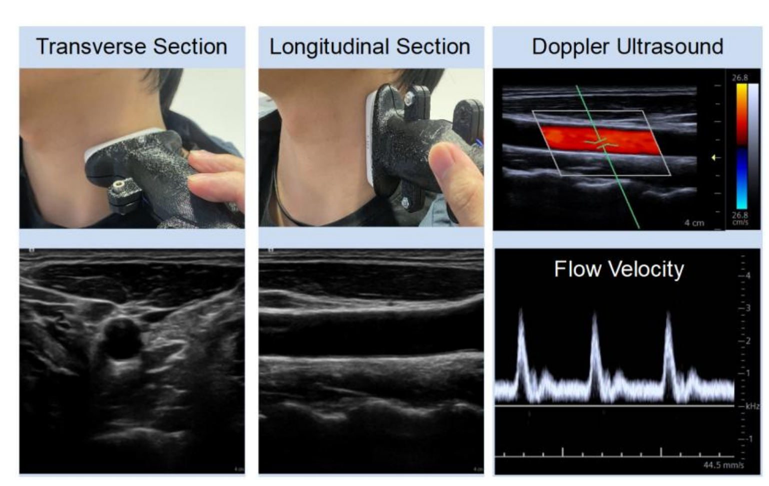
Imitation Learning for Manipulation



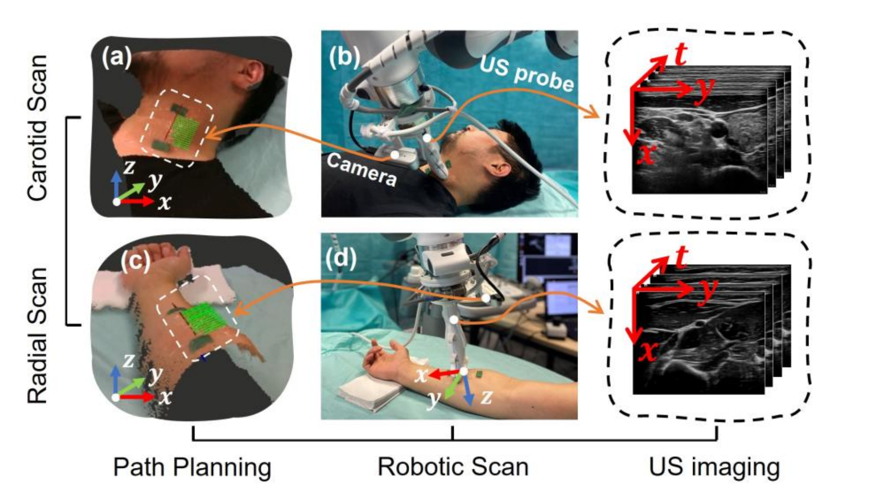
- **Dual-branch diffusion policy:** A dual-branch architecture balances visual and proprioceptive inputs, improving adaptability and failure recovery in precise manipulation.
- **Koopman-boosted visual dynamics:** Deep Koopman operators are integrated to model visual dynamics and enhance representation quality while avoiding mode collapse.
- **Uncertainty-aware action aggregation:** Temporally overlapping action chunks are fused using test-time diffusion loss as an uncertainty measure, significantly improving success rates.

D. Huang, N. Navab, and Z. Jiang. "Improving Robustness to Out-of-Distribution States in Imitation Learning via Deep Koopman-Boosted Diffusion Policy." ***IEEE Transactions on Robotics (TRO)***, 2025.

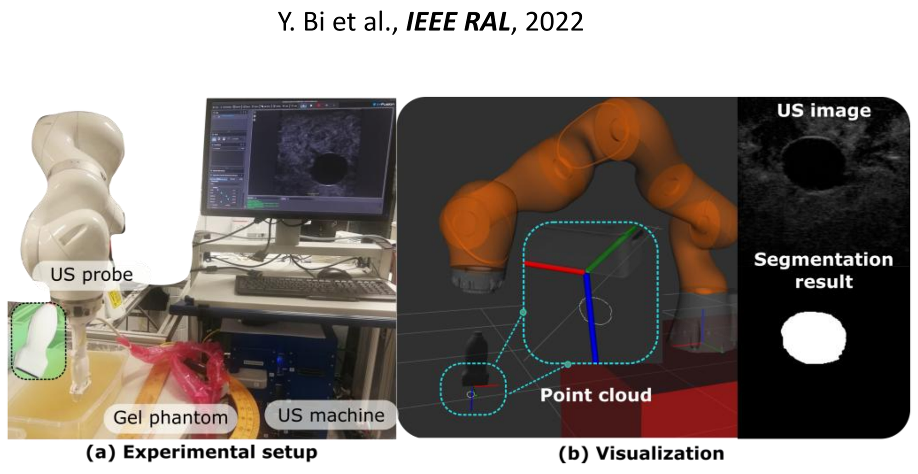
Robotic Ultrasound Scanning



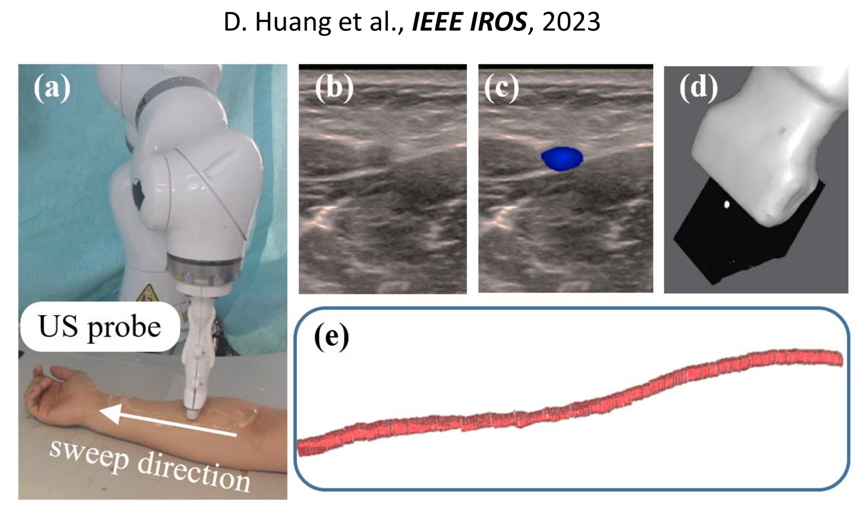
Y. Bi et al., ***IEEE RAL***, 2022



D. Huang et al., ***IEEE IROS***, 2023



Z. Jiang. et al., ***IEEE TIE***, 2021



Z. Jiang. et al., ***IEEE TASE***, 2022