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Closing the Loop at the Bedside: Real-Time AI Feedback Design for Cardiac Ultrasound Guidance in a Multi-Team Medical-AI Platform

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Introduction/Background

Cardiac point-of-care ultrasound (POCUS) could bring diagnostic imaging to rural care, where generalists outnumber expert sonographers. But acquiring optimal views takes skill generalists often do not have, and existing AI guidance tools mostly demonstrate a single model. We describe the cardiac guidance component of a multi-team AI platform: models combined into a real-time feedback loop that steers operators toward the target view.

Methods/Intervention

Built on a robotics middleware (ROS 2), the multi-procedure platform's cardiac task launches nineteen processes: AI models and services from independent teams. These processes run separately, each assigned a GPU, and exchange data through message topics; a fault in one cannot crash the rest. The cardiac process presents two primary interface elements. A 3D probe-guidance widget shows how to move: fusing camera-based probe-tip localization, a patient body mesh, probe orientation, and image-based pose inference, it renders the live probe beside a ghost target on the patient's chest. The gap indicates direction and distance-to-goal. Annotated ultrasound shows what movement achieves: the live image overlaid with chamber landmarks and a traffic-light quality border. Sustained image quality triggers ejection-fraction estimation over a quality-gated buffer, validating the acquired view. Latency is budgeted at 1.5× the probe's 20 Hz maximum, so feedback stays responsive to the hand. Every element is runtime-configurable, so only relevant cues appear.

Results/Outcome

In integration testing, the cardiac task ran on a dual-GPU workstation; both feedback streams kept pace with the probe, frame for frame. Reaching that rate took repeated profiling: message serialization, software rendering, and model placement each initially broke the frame budget. In live scanning, operators following the cues aligned the probe, reached adequate image quality, and obtained an ejection fraction.

Conclusion

The feedback loop integrated independently developed models into one decision aid: 3D cues direct movement, the quality border reports adequacy, and a measurement confirms it. Isolated processes and latency budgets made the loop real time; a simple interface kept it usable.

Statement of Impact

For teams bringing AI guidance to POCUS, we recommend designing the operator's feedback loop first (how to move, what it achieves, when it is confirmed), then engineering it to run in real time.

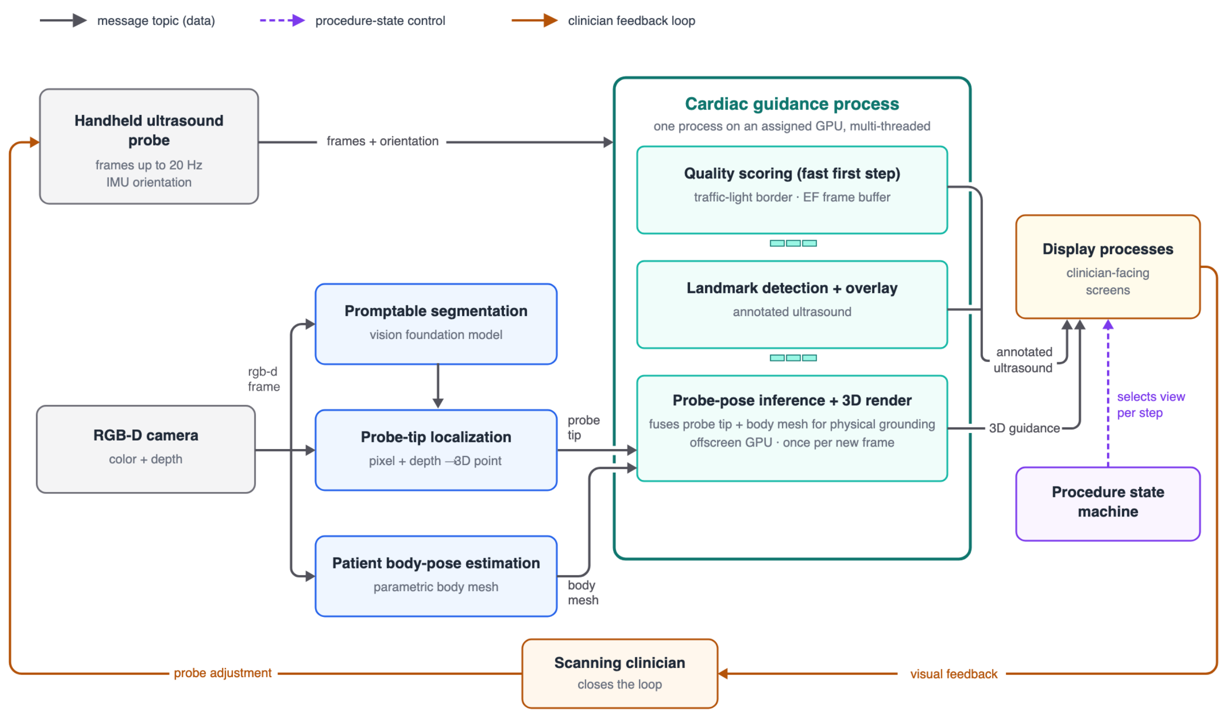

Figure 1. The cardiac guidance feedback loop within the multi-process AI platform. Each AI model or service runs in its own process with an assigned GPU; the guidance process composes peer models' outputs (probe-tip localization, patient body pose) with its own inference to render annotated ultrasound and a 3D probe cue in real time. Solid gray arrows are message topics; the dashed purple arrow is procedure-state control; amber arrows are the human loop: the clinician sees the guidance and adjusts the probe. Inter-stage queues are depth-limited, latest-wins.

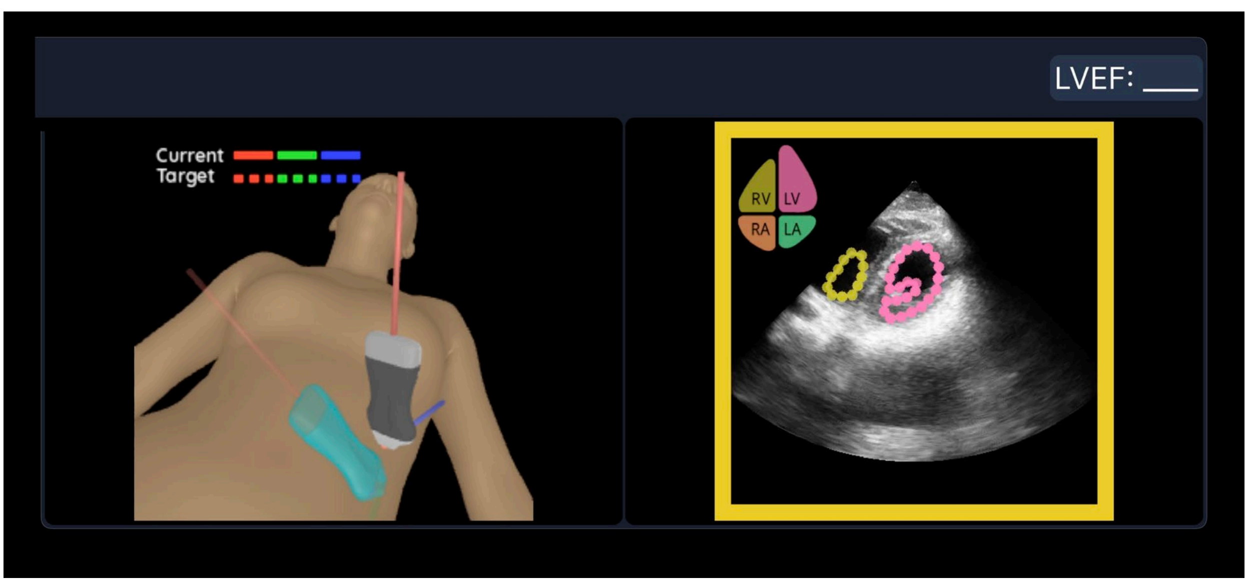

Figure 2. The clinician-facing cardiac guidance display (integration-test capture). Left: the 3D probe-guidance widget, with live probe and ghost target rendered on the patient's body mesh (“Current” and “Target” axes, drawn as solid, semi-transparent bars; the on-screen legend dashes the target only for clarity); the gap between them indicates direction and distance-to-goal. Right: annotated ultrasound, showing chamber-landmark contours with color legend (RV, right ventricle; LV, left ventricle; RA, right

atrium; LA, left atrium) inside the traffic-light quality border (yellow shown). Top right: the ejection-fraction readout, populated once image quality is sustained.

Keywords

Point-of-care Ultrasound; Echocardiography; AI-guided Acquisition; Clinical AI Integration; Real-time Inference; Human-AI Interaction