Deferra: Trajectory-Conditioned Selective AI Assistance

Surgery, anesthesiology, interventional medicine, and closed-loop reacquisition

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Abstract

Deferra is a trajectory-conditioned clinical-assistance controller designed to decide not only *what* an AI system could say or do, but *whether the current patient, procedural field, and intervention history support assistance at all*. The system separates observation failure from trajectory departure and from change in the intervention-response relation. It can remain silent during coherent execution, withdraw guidance when the measurement cannot support a determination, request or optimize reacquisition, and escalate assistance when a supported departure or changed response relation is detected. The architecture applies to surgery, anesthesiology, critical care, image-guided intervention, robotic systems, infusion, ventilation, and other closed-loop clinical settings. Current evidence is retrospective: robotic kinematics, laparoscopic video, critical-care control, sepsis physiology, and longitudinal glioblastoma embodiments demonstrate trajectory/departure behavior and selective-routing feasibility, not prospective clinical benefit.

Core distinction. Conventional assistive AI is often evaluated on the accuracy of a prediction or annotation. Deferra adds a supervisory question: *does the AI have enough supported, current information to assist now, and has the intervention changed the system enough that the old response model is stale?*

1 The clinical problem

Clinical intervention changes the system being observed. Tissue is cut or retracted, an instrument is repositioned, a drug is titrated, ventilation is changed, a catheter advances, or a device alters physiology. A model that described the system before the action can therefore become stale after the action. At the same time, continuous AI commentary can be unnecessary or distracting during stable expert execution.

Deferra treats the patient, clinician, instrument, sensor, and AI output as a coupled dynamic system. It maintains an expected short-horizon trajectory, observes the actual post-action state, measures departure, evaluates whether the intervention-response relation remains coherent, checks whether the current observation supports a determination, and routes assistance accordingly.

2 The Deferra state

A non-limiting Deferra state can be written

$$Z_t = \{x_t, u_t, \widehat{x}_{t+h}, D_t, C_t, S_t, P_t, R_t\},$$

where x_t is the current patient/procedural state, u_t the intervention or action, $\widehat{x}_{t+h}$ an expected future state, D_t a departure quantity, C_t a changed-response or coherence state, S_t observation/support state, P_t procedure phase or local context, and R_t additional risk/controllability constraints.

The controller may select among monitor/defer, alert, annotate, recommend, confirm, constrain, assist, escalate, abstain/safe-state, and return/de-escalate. Outputs can be visual, auditory, haptic, textual, navigational, anatomical, dosing, trajectory, or bounded physical-control signals.

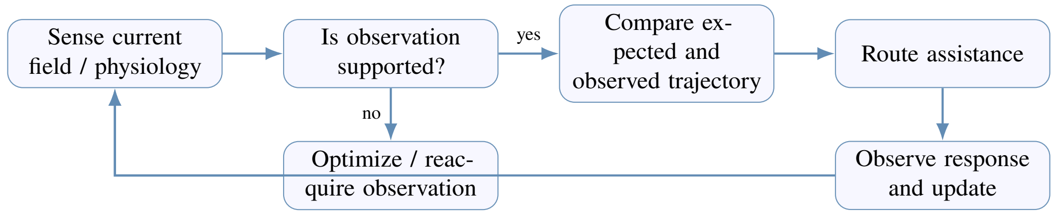

Figure 1: Deferra separates measurement support from trajectory and response-law assessment. Reacquisition is a first-class controller action rather than a generic reset.

3 Three failure modes that should not be conflated

3.1 Measurement or support failure

The current camera view, waveform, sensor configuration, or multimodal state may be inadequate for the requested determination. In that state Deferra should not continue projecting confident guidance from a degraded substrate. It can withdraw overlays, withhold assistance, request an additional observation, alter an acquisition parameter, reposition a camera, or route to another sensor/modal source.

3.2 Trajectory departure

The observation can be adequate while the physical course departs from the expected path. A departure residual, visual-motion change, kinematic discrepancy, physiologic deviation, or phase-conditioned error can then justify a different assistance state.

3.3 Changed intervention-response relation

A single residual need not mean that the governing relationship changed. Deferra therefore permits a separate serial response-history or changed-law state: after an intervention, does the relation between state, action, and next state remain coherent with the prior relation? If not, the system can stop reusing the pre-intervention mapping and update the expected trajectory or assistance policy.

4 Surgical and computer-vision embodiment

A surgical embodiment can ingest laparoscopic, endoscopic, microscopic, fluoroscopic, ultrasound, open-surgery, or robotic video together with instrument kinematics and contextual data. Sequential image representations can be compared by motion, second-order change, predicted-state residual, optical flow, segmentation change, feature-track residual, anatomical topology, scene graph, phase-conditioned distribution, or combinations. Spatial attribution can localize the anatomical region, instrument, or field component contributing to a departure state.

The clinician-facing layer may activate anatomical labels, safe-plane overlays, phase-transition cues, instrument-path guidance, visibility warnings, bleeding/dissection guidance, bounded robotic constraints, or a request for additional imaging. A tracked-instrument embodiment can also use position, orientation, force, torque, velocity, gesture, and curvature. Camera repositioning is an explicit reacquisition action.

4.1 Optimize View / reacquisition loop

The public surgical demonstrator makes this distinction visible. If focus, glare, smoke/occlusion, or view geometry degrades support, Deferra enters a withhold/reacquire state and exposes an **Optimize View** action. The demonstrator then adjusts acquisition variables, restores a supported view, reacquires the operative context, and only then returns to defer or supported assistance. In a physical implementation, the corresponding actions could be recommendations to the operator, camera-system settings, additional imaging, or bounded device-control signals.

This is different from a reset button: it represents a closed-loop acquisition decision tied to the inference the system is trying to support.

5 Anesthesiology and physiologic-control embodiment

Deferra is not limited to visible anatomy. In anesthesiology or critical care, the state can include arterial pressure, oxygenation, respiratory variables, infusion settings, ventilation, laboratory measures, drug titration, and clinician actions. The same controller logic asks whether the measurement is adequate, whether physiology remains on the expected course under the current intervention, whether serial response has changed, and whether AI assistance is justified.

The output may remain silent during coherent clinician control; request a better measurement; alert to departure; recommend or confirm a dose/ventilator change; constrain an automated controller; or escalate to a safe state. Different processes can use different time windows because the observable response to an intervention need not occur on the same timescale.

6 Auditability and the surgical transcript

Every Deferra action should be reconstructable. A session log can record expected state, observed state, support state, phase/context, departure, response-relation state, assistance route, AI output, clinician response, executed action, reacquisition, and subsequent state. The public demonstrator turns this into a downloadable session transcript so a viewer can see not only the final recommendation but *when Deferra intervened, when it stayed silent, why it withdrew, and what changed before it resumed*.

A clinical production log would require the security, retention, identity, and regulatory controls appropriate to the deployment. The demo transcript is a product demonstration, not a clinical record.

7 Retrospective validation map

Embodiment	Released evidence and interpretation
JIGSAWS robotic surgery	336,628 kinematic states across suturing, needle passing, and knot tying by eight operators. High-surprise states were enriched near gesture transitions; at a 97.5th-percentile gate enrichment was about 2.43-fold for knot tying and 2.44-fold for needle passing, with gated states carrying roughly four-to-five-fold greater instantaneous motion. This supports transition localization, not prospective surgical benefit.
Cholec80 video	46,079 sampled visual states from 20 complete laparoscopic cholecystectomy procedures. The phase-blind departure model showed 1.84-fold enrichment within 30 seconds of withheld phase transitions and 2.13-fold within 10 seconds at the 95th-percentile gate, reaching about 2.32-fold at the 97.5th percentile. This supports visual trajectory sensitivity to transitions/complexity.
MIMIC-IV MAP control	Retrospective routing around norepinephrine-anchored MAP-control events separated coherent and departure states. In the released departure stratum an intervention-conditioned augmented route reached about 46.9% directional accuracy versus 20.5% clinician and 19.6% standard model; this is a retrospective routing result, not a deployment claim.
PhysioNet sepsis	90,626 acute physiologic states; high-surprise states had roughly twice the mean trajectory departure of low-surprise states (131.5 vs 65.4) even while a standard pre-intervention model retained high average R^2. This separates average prediction from individual departure.
LUMIERE glioblastoma	50-patient longitudinal embodiment showed that longer observation windows could reveal treatment-created deformation that short windows missed. The result supports frequency dependence, not clinical efficacy.

Table 1: Current Deferra evidence spans visual, kinematic, physiologic, and longitudinal intervention settings. Each result supports a different part of the architecture.

8 What Deferra is relative to other AI products

Deferra is not primarily an anatomy-labeling system, a phase classifier, a surgical robot, an alarm score, or a generic uncertainty monitor. Those systems can be inputs or downstream tools. Deferra's distinctive role is to supervise the *right to assist*: it combines current observation support with procedure/physiology context, expected trajectory, intervention response, and changed-law evidence to decide whether assistance should remain silent, be withdrawn, be reacquired, or become active.

In that sense, scene recognition answers "what is in the field?" and a predictive model answers "what is likely next?" Deferra adds "is the current evidence adequate, is this still the same operative/physiologic relation, and should AI intervene now?"

9 Boundaries

Current validation is retrospective and does not establish clinical benefit, complication reduction, autonomous safety, anatomical-recognition accuracy, or regulatory clearance. Demo overlays and controlled perturbations illustrate the controller architecture and should not be read as a claim that the public browser demo is a validated clinical computer-vision system. Prospective evaluation would require procedure-specific support calibration, human-factors testing, device integration, safety interlocks, and clinical validation.

Intellectual property, competing interests, funding, and use

Relevant methods and computational systems are the subject of previously filed U.S. provisional patent applications. Protected production implementations, calibration internals, actuation policies, and deployment orchestration are not disclosed here. Publication does not grant a patent or commercial software license.

The author is Founder of Conquer Medical Health and has financial and intellectual-property interests in the technologies described. No external funding supported preparation of this technical report.

Use of AI-assisted tools

AI-assisted tools were used for editorial and software-documentation support. The author determined the scientific claims, supplied the underlying analyses and validation artifacts, and reviewed the numerical content and final report.

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