SAFE-Gate: Six-Gate Parallel Expert System Architecture

STAGE 1: Parallel Gate Evaluation

STAGE 2: Conservative Merging

STAGE 3: Output Generation

LEGEND

Rule-based gate

Statistical gate

Bayesian gate

Completeness gate

G1: Critical Red Flags
⚠️ Rule-based
Emergency guidelines
Unstable vitals, neuro deficits

G2: Cardiovascular Risk
❤️ Statistical
Risk factor scoring
Age, HTN, DM, AFib

G3: Data Quality
✓ Completeness
Field validation
Missing data check

**Patient Clinical Data
(52 features)**

G4: Syndrome Matching
🔍 Rule-based
TiTrATE framework
BPPV, vestibular neuritis

⚡ KEY INNOVATION

MIN selection (not averaging) prevents safety signal dilution

**If ANY gate signals critical:
→ Final output IS critical**

G5: Uncertainty Quantification
📊 Bayesian
MC Dropout
Epistemic uncertainty

G6: Temporal Analysis
⏱️ State machine
Symptom evolution
Time-to-presentation

Conservative Merging

**MIN Operator
(Lattice Infimum ⊓)**

Selects MOST CONSERVATIVE assessment across all gates

Risk Lattice Ordering:

R* (Abstain) ⊑
R1 (Critical) ⊑
R2 (High-risk) ⊑
R3 (Moderate) ⊑
R4 (Low-risk) ⊑
R5 (Minimal)

Risk Tier Assignment

R* = Defer to clinician
R1 = Critical (<5 min)
R2 = High-risk (<15 min)
R3 = Moderate (30-120 min)
R4 = Low-risk (1-4 hrs)
R5 = Safe discharge

Audit Trail (Explainability)

✓ Final tier: R_final
✓ Enforcing gate: G_enforce
✓ Gate outputs: {r₁, r₂, r₃, r₄, r₅, r₆}
✓ Clinical rationale
✓ Triggered rules/features
✓ Confidence scores

Safety Guarantees

✓ Zero false negatives (R1-R2)
✓ 100% critical sensitivity
✓ Conservative over-triage
✓ Real-time (<2ms)