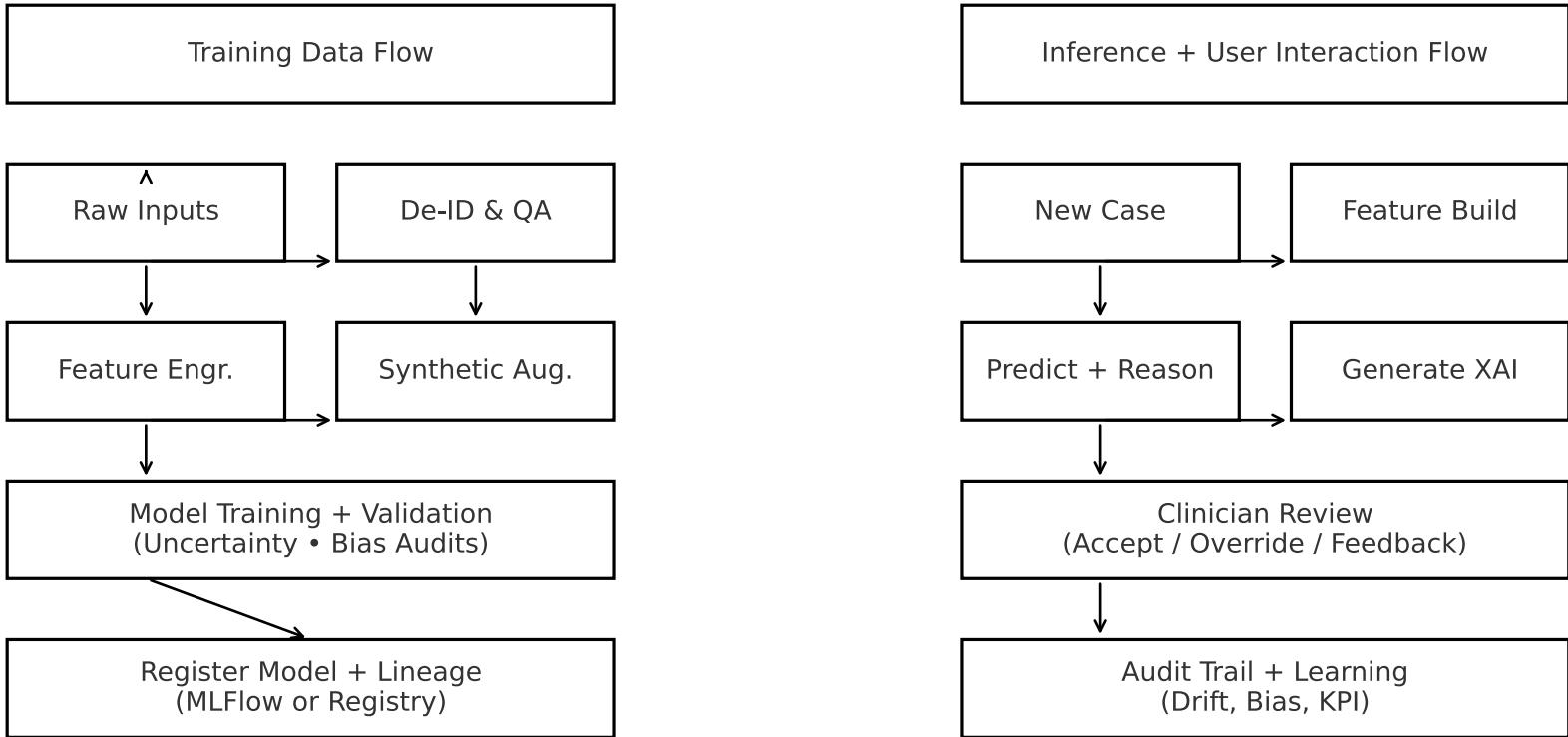


Security • Privacy • RBAC • Audit Trails • MLOps/Monitoring • Bias & Drift Audits

1) High-Level System Architecture



		Presentation & UX Clinician UI • Patient Explainability • Dashboards • What-If Tools
		Explainability & Visualization Saliency • Counterfactuals • Case-based • Reasoning Graphs
		Application Services CDS APIs • Routing • Orchestration • Alerting
		Reasoning & Knowledge Cognitive Network • Causal Graphs • Ontologies (SNOMED/ICD)
		Analytics & Modeling Generative Models • Predictive Models • Uncertainty • Scenario Sims
		Data Management Data Lake • Feature Store • Metadata • Lineage • PII Vault
		Integration & Ingestion HL7/FHIR • DICOM • Streaming (Vitals) • ETL • De-ID
		Security, Compliance, Governance RBAC • Audit Trails • Consent • Bias/Drift Monitoring
External Interfaces Hospitals • Labs • Imaging Centers • Regulators • Patients	MLOps & Operations Model Registry • CI/CD • Monitoring • Rollback • Canary	Admin & Ops Security • Compliance • DevOps/MLOps

A. Multimodal Harmonization & Feature Fusion • Purpose: Normalize/align EHR, imaging, labs, genomics, and wearables into a unified feature space. • Logic: Schema mapping → Missingness-aware transforms → Modality encoders → Attention-based fusion. B. Synthetic Data Generation with Safeguards • Purpose: Address data scarcity/class imbalance and privacy via conditional diffusion/GAN/transformer sampling. • Logic: Condition on metadata; sample; validate against clinical constraints & knowledge bases; log lineage. C. Cognitive Network Reasoning (Causal/Relational) • Purpose: Produce interpretable reasoning paths linking symptoms → diagnoses → treatments/risk. • Logic: Knowledge graph + causal weights; path search with Bayesian or energy-based scoring; top-k chains. D. Explainability & Counterfactual Generation • Purpose: Provide visual/textual explanations clinicians can trust; simulate “what would change the decision?” • Logic: Attribution over features; retrieve similar/synthetic cases; constrained counterfactual search. E. Early Warning Detection (Streaming) • Purpose: Real-time risk alerts (e.g., sepsis) with interpretable factors. • Logic: Temporal features + EWMA/sequence model; uncertainty thresholds; human-in-the-loop escalation. F. Uncertainty Quantification & Risk Triage • Purpose: Defer uncertain cases; calibrate risk scores. • Logic: Monte-Carlo dropout or ensembles; calibration; thresholds mapped to action policies. G. Bias, Drift, and Compliance Auditing • Purpose: Detect performance drift and subgroup disparities; maintain audit trails. • Logic: Rolling metrics; population stability; fairness gaps; regulator-ready reports. H. Visual Reasoning Framework Layout • Purpose: Render cognitive chains as concise graphs for clinicians. • Logic: DAG layout (levels: evidence → hypotheses → interventions); annotate contributions/uncertainty.

Assumptions made to resolve ambiguities:

- Standards: HL7/FHIR for EHR, DICOM for imaging, LIS for labs, common genomics formats (VCF) for genetics.
- Knowledge bases: Uses standard ontologies (e.g., SNOMED CT, ICD) integrated into the cognitive network.
- Privacy: De-identification (direct/indirect identifiers) and consent management precede model access.
- Infrastructure: Modular microservices; on-prem or cloud; RBAC; full audit/logging.
- Explainability: Clinician-facing visuals prioritize clarity over model internals; supports case-based reasoning.
- Limitations & scope:

 - Provided algorithms are reference implementations for system behavior; not clinical devices.
 - Real deployments require validation with clinical experts and regulatory review.