Multimodal AI: Reconstructing and Benchmarking the INSPECT Framework

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INTRODUCTION

- Replicating complex clinical pipelines for **Multimodal AI benchmarks** is a major **data engineering challenge**.
- Stanford's **INSPECT dataset (19,402 patients)** links **longitudinal EHRs** with **CT Angiograms (CTPAs)** to predict **7 key pulmonary embolism (PE) endpoints** (e.g., mortality, readmission).
- **Reconstruct** the complete, end-to-end INSPECT framework at MEDomicsLab (RI-MUHC) to **establish** a high-performance local benchmark for **multimodal clinical AI validation**.

METHODS

Phase I: Structured EHR Engineering:

- Mapped relational EHR tables into standardized schema.
- Chronologically flattened patient timelines while enforcing clinical sequence integrity.
- Analyzed through **LightGBM** and **MOTOR**

Phase II: Deep Learning Vision Pipeline:

- **Fine-tuned** a ResNetV2-101x3 backbone on the external RSNA-STR PE dataset (**12 000 CTPAs**).
- Processed slice vectors via **RNN/Transformer models** to capture 3D contextual flow

Additional data capture:

- Design a **temporal EHR feature extractor**
- **Extract** CNN-processed **embeddings** for future analysis/modeling
- **Extract** RNN/Transformer **embeddings** for future analysis/modeling

Key Performance Indicators:

- Comparison of obtained AUROCs with INSPECT

EXPERIMENTAL FRAMEWORK & BENCHMARKING

INSPECT FRAMEWORK

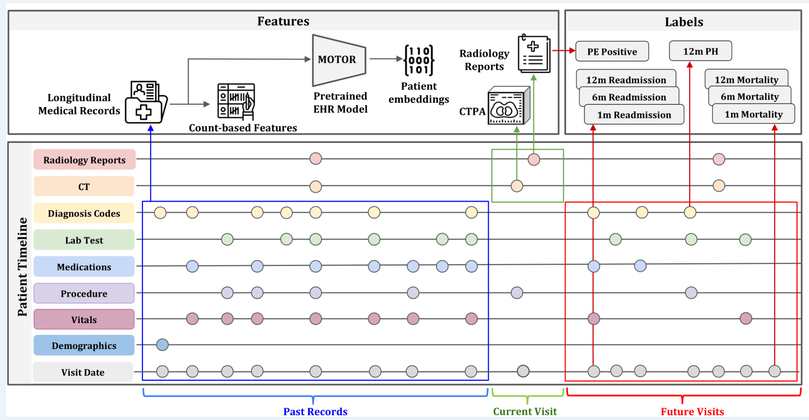


Figure 1. The INSPECT Framework Architecture. Longitudinal EHR histories (*Past Records*) generate tabular and pre-trained MOTOR embeddings, while current imaging and radiology reports drive multi-task clinical predictions (*Future Visits*) across 7 endpoints.

BENCHMARK RESULTS

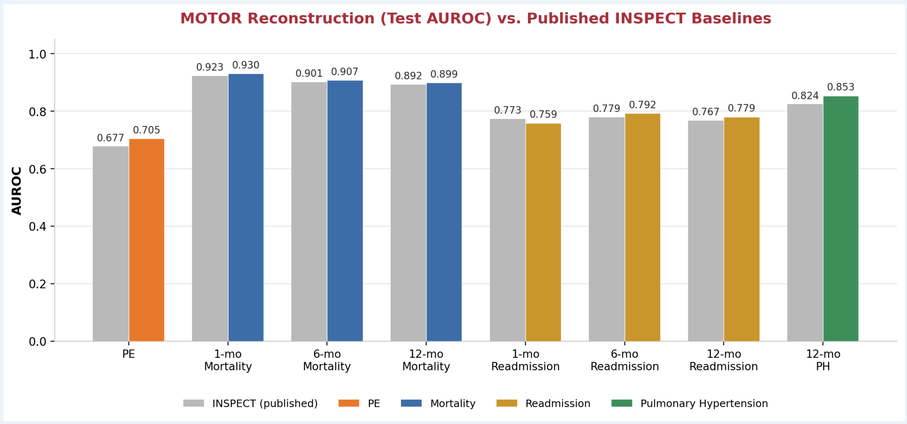


Figure 2. Sample Benchmark Results. Comparison of INSPECT baselines with reconstructed dataset using the MOTOR model on diagnostic task and 7 prognostic tasks.

INTEGRATION & SYSTEM PIPELINE

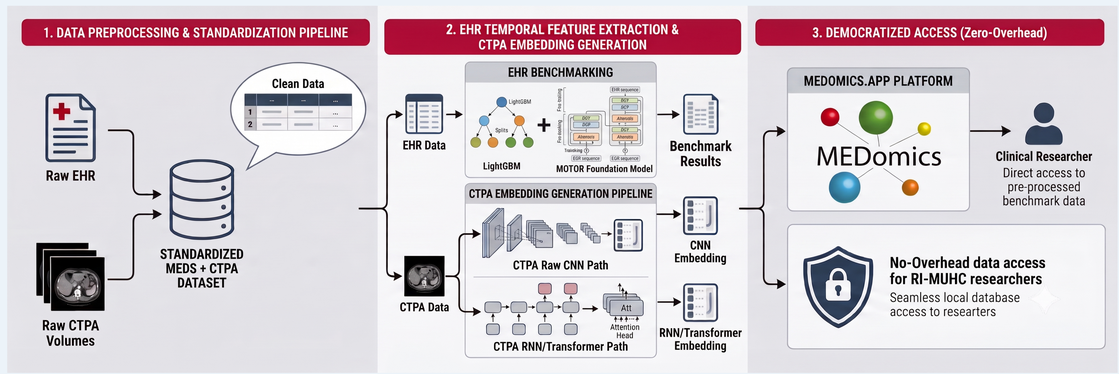


Figure 3. End-to-End Pipeline for Multimodal Feature Extraction and Democratized Platform Integration. Workflow showing the ingestion of raw EHR and CTPA data, standardized feature extraction, and secure, zero-overhead database access via the MEDomics ecosystem.

Results

Key Highlights:

LightGBM: 12-Month Pulmonary Hypertension (PH):

- **AUROC:0.92** *(11% performance gain over original publication)*
- **Sensitivity:0.72 | Specificity:0.94**
- **Cohort Prevalence:14.5%**
- **Baseline Parity:** Initial tabular LightGBM models achieved high predictive fidelity across all benchmarked clinical endpoints.
- **Feature extractor:** tool to customize data extraction from the EHRs

MOTOR:

- **Consistent with baseline:** Our reconstruction outperformed INSPECT in 7 out of 8 endpoints but marginally, lending credibility to the data

CTPAs:

- **Closing the performance gap** by experimenting with different fixes within the boundaries of the original work

General:

- **Platform Integration:** Plans to consolidate longitudinal EHR artifacts and CTPA vectors directly into the **MEDomics ecosystem (MEDomics.app)**.
- **Zero-Overhead Access:** Eliminates heavy data preprocessing for end-users, enabling immediate validation of custom multimodal models.

Conclusion

- Infrastructure Built: Established a scalable, local research infrastructure at the RI-MUHC for **benchmarking multimodal clinical models**.
- Democratizing AI: Fully integrated with the MEDomics platform, giving interdisciplinary teams of clinicians and computer scientists **instant access to standardized, high-dimensional** PE research workflows.

Reference and Contacts

- Huang, S.-C., *et al.* (2023). INSPECT: A Multimodal Dataset for Pulmonary Embolism Diagnosis and Prognosis. *arXiv preprint arXiv:2311.10798*.

- MEDomics Lab - **medomicslab.com**
- MEDomics application - **medomics.app**
- Questions:

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