AI System for Disease Detection and Risk Prediction from Longitudinal Multi-Modal Medical Data

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Background & Unmet Need

- Much of biomedical research and healthcare is based on characterizing and responding to relevant changes in data that have been collected over time, such as imaging, laboratory results, pathology, free-text clinical notes, and wearable signals
- Many artificial intelligence (AI)-based diagnostic tools rely primarily on single-timepoint data—such as a single imaging scan, a one-off lab reading, or both—when assessing a patient's health status
- This can result in suboptimal early detection or less accurate predictions of disease course, since meaningful patterns often emerge over multiple patient visits
- Classical risk models for disease prediction rely on relatively few variables and do not exploit the richness of longitudinal image data or other repeated clinical information
- **Unmet Need:** Methods for integrating multimodal longitudinal data to support clinical decisions

Technology Overview

- **The Technology:** A time-aware AI architecture which integrates multimodal longitudinal data to provide improved clinical decision support
- The system accommodates virtually any data type including imaging data, lab values, pathology, clinical notes, genomic data, and wearable signals
- The system learns temporal relationships across a patient's entire clinical history to perform a variety of tasks (e.g., disease classification, regression, multi-label tasks, survival/risk estimation)
- **PoC Data:** The inventors developed a longitudinal model for mammogram risk prediction with superior predictive value (AUC 0.92 at 1-year follow up vs. 0.9 and 0.83 for comparator models)
- An additional model for AD progression in normal vs. MCI patients based on multimodal inputs (cognitive assessments, MRI, genetic, and clinical data) with an AUC curve improved by up to 15% over state-of-the-art models

Inventors:
Mert Sabuncu
Batuhan Karaman

Patents:
Provisional Filed

Publications:

Karaman et al. *Big Data Mining and Analytics*. 2026.
Khawaled. *MIDL 2026 Poster*. 2026. (poster)
Kim et al. *Proc Natl Acad Sci USA*. 2025.
Nguyen et al. *MELBA*. *2024.*
Karaman et al. *MICCAI 2024*. 2024. (conference paper)

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AD: Alzheimer's Disease; AI: Artificial Intelligence; MCI: Mild Cognitive Impairment

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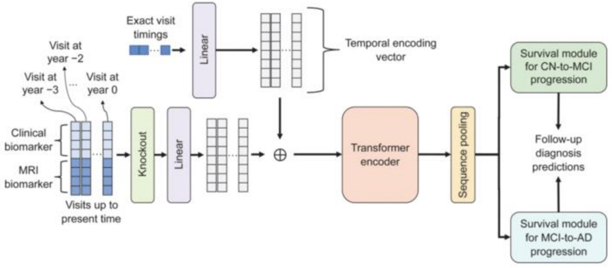
Technology Applications

- Clinical decision support (e.g., diagnosis, detection, risk stratification, therapy selection, monitoring)
- Population health management (e.g., patient outreach and screening, proactive interventions, healthcare policy and budget planning)
- Research and clinical trials (e.g., longitudinal outcome analysis, biomarker discovery, adaptive trial design)

Technology Advantages

- The architecture is flexible and can incorporate virtually any data modality or set of data modalities
- The architecture design enables robust handling missing or asynchronous data without severely degrading performance
- The system is generalizable; it scales to large datasets and can be applied to numerous clinical domains (e.g., oncology, neurology, and cardiology)

Supporting Data / Figures



Model	Longitudinal data modality	Sequential network architecture	Three-year MCI-to-AD AUROC (%)
Cui et al.[3]	MRI	RNN	73.03
VGG-TSwinformer[8]	MRI	Transformer	81.53
LongForMAD[12]	MRI	Transformer	78.65
LongForMAD[12]	MRI + COGN	Transformer	92.03
Li and Liu[25]	MRI	–	74.60
BMNet[26]	MRI	–	79.26
LSM-AD (ours)	MRI	Transformer	81.33
LSM-AD (ours)	MRI + COGN	Transformer	92.54

Figure 1: The LSM-AD model integrates clinical and MRI biomarkers over a series of patient visits to predict control vs. MCI-to-AD progression and outperforms prior state-of-the art longitudinal models.

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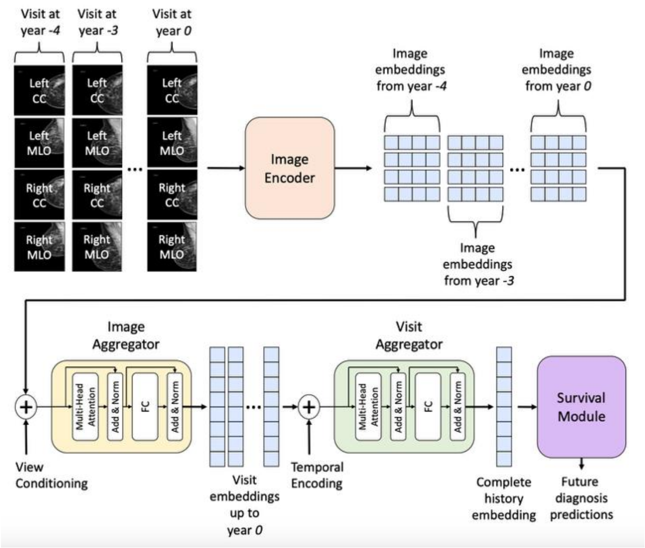

Model	History duration	C-index	Follow-up year ROCAUC 1-year	2-year	3-year	4-year	5-year
Image-Only DL [18]	0	0.75 (0.73–0.77)	0.83 (0.81–0.86)	0.79 (0.77–0.81)	0.75 (0.73–0.77)	0.73 (0.71–0.75)	0.71 (0.69–0.73)
Mirai [20]	0	0.81 (0.79–0.82)	0.90 (0.89–0.92)	0.86 (0.84–0.88)	0.82 (0.80–0.84)	0.80 (0.79–0.82)	0.78 (0.76–0.80)
LoMaR (Ours)	0	0.81 (0.78–0.83)	0.92 (0.90–0.94)	0.84 (0.83–0.86)	0.84 (0.83–0.85)	0.82 (0.81–0.83)	0.81 (0.80–0.82)
LoMaR (Ours)	1*	0.82 (0.78–0.83)	0.92 (0.90–0.94)	0.85 (0.83–0.86)	0.84 (0.83–0.85)	0.82 (0.81–0.83)	0.81 (0.80–0.82)
LoMaR (Ours)	2*	0.82 (0.78–0.83)	0.92 (0.90–0.94)	0.84 (0.83–0.86)	0.84 (0.83–0.85)	0.82 (0.81–0.83)	0.83 (0.82–0.84)
LoMaR (Ours)	3*	0.82 (0.78–0.83)	0.92 (0.90–0.94)	0.84 (0.83–0.86)	0.84 (0.82–0.85)	0.83 (0.82–0.84)	0.85 (0.84–0.86)
LoMaR (Ours)	4*	0.82 (0.78–0.83)	0.92 (0.90–0.93)	0.84 (0.83–0.86)	0.84 (0.83–0.86)	0.85 (0.84–0.86)	0.86 (0.85–0.87)
LoMaR (Ours)	4†	0.82 (0.78–0.83)	0.92 (0.90–0.93)	0.84 (0.83–0.86)	0.84 (0.83–0.86)	0.84 (0.84–0.86)	0.84 (0.85–0.87)

Figure 2: The LoMaR model integrates time-series mammography data over time to predict breast cancer risk and outperforms single visit-state-of-the-art prediction models.

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