NeuroChron: AI-Driven Brain Age Detection for Early Neurological Risk Identification

Gerson Estrada, Ishaani Pradeep, Nicholas Kim, and Nicole Popenko
Alfred E. Mann Department of Biomedical Engineering, University of Southern California

Background

Neurodegenerative diseases such as Alzheimer's and Parkinson's develop silently for years before clinical symptoms emerge. While early detection is critical for effective intervention, current diagnostic tools struggle to identify subtle structural brain changes during these early stages. By the time cognitive impairment is detected, irreversible neurological damage may have already occurred, limiting treatment effectiveness. As a result, early identification of abnormal brain aging is critical for improving patient outcomes and reducing long-term healthcare costs.

Despite advances in neuroimaging and machine learning, clinicians still lack accessible tools that can reliably distinguish normal aging from early pathological change. Many existing brain-age and MRI analysis tools function as "black boxes," providing limited interpretability and minimal insight into why a prediction was made. Other approaches remain research-grade, lacking usability and integration into real clinical workflows, which reduces physician trust and adoption.

NeuroChron addresses this unmet need by transforming routine MRI scans into transparent, explainable brain-age insights. By combining deep learning with voxel-level saliency maps and a clinician-centered interface, NeuroChron enables physicians to understand where abnormal aging may be occurring and supports earlier, more informed neurological risk assessment.

Research Question

Can explainable, research-grade AI be translated into a clinically usable brain-age tool for non-AI expert clinicians?

Clinical Impact & Applications

NeuroChron improves trust, transparency, and actionability in AI-assisted brain imaging across neurology, radiology, and research settings for screening, longitudinal monitoring, and early-stage disease tracking

- **Early Risk Identification:** Detect abnormal brain aging patterns before overt symptoms appear
- **Explainable AI:** Voxel-level saliency maps highlight specific brain regions driving age predictions, increasing transparency, interpretability, and physician trust compared to black-box models.
- **Decision Support:** Assist clinicians in differentiating normal aging from potentially pathological change. Intended to support, but not replace, clinical judgment
- **Workflow Integration:** Support common imaging formats(DICOM, NIfTI, MGZ), enabling integration without requiring specialized AI expertise.
- Target Users: Neurologists, radiologists, primary care physicians, and imaging centers.

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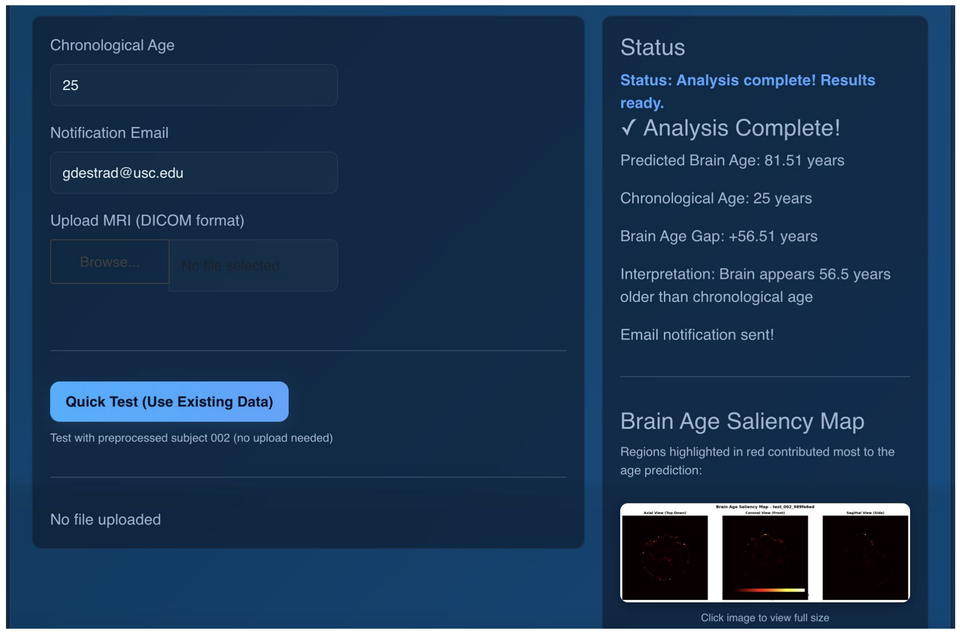
Design

NeuroChron is a full-stack software platform that integrates MRI preprocessing, deep learning, and explainable AI into a single clinical workflow.



- **Input:** Routine T1-weighted brain MRI + patient chronological age
- **Preprocessing:** Automated MRI standardization and segmentation (FreeSurfer, Docker)
- **ML Model:** Deep learning brain-age estimation
- **Outputs:**
  - Predicted biological brain age
  - Brain-age gap (biological vs. chronological age)
  - Voxel-level saliency heat maps highlighting influential brain regions
- **Frontend:** Clinician-friendly GUI with automated email notification upon analysis completion

The system is designed to integrate seamlessly into existing MRI pipelines while prioritizing usability and interpretability.

Future Development

- Clinical validation with neurologist feedback
- **Web-based deployment** for scalable clinical access
- **Performance optimization** to reduce MRI preprocessing time
- Regulatory pathway exploration as a clinical decision-support tool
- Expansion to direct implementation of tools for longitudinal brain-age tracking
- Disease-specific pattern recognition (Alzheimer's, Parkinson's)

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