SciVizHub for Biomedical Education: AIM-AHEAD Partnership Concept

Biomedical Applications Grid

Existing Visualizations and Their Health Applications

Visualization	Core Concept	Direct Health Applications	Relevance to Health Equity Research
Fourier Transforms	Signal decomposition into frequency components	• MRI/CT image reconstruction • ECG/EEG signal processing • Ultrasound imaging • Noise filtering in medical devices • Spectroscopy data analysis	Enables understanding of medical imaging technology critical for diagnostic disparities research
Compression Algorithms	Data size reduction techniques	• Medical imaging storage and transmission • Genomic data compression • Electronic health record optimization • Telemedicine infrastructure	Supports remote healthcare delivery to underserved communities
Bayes' Theorem	Probabilistic inference	• Clinical diagnostic reasoning • Medical screening test interpretation • Genetic risk assessment • Disease prevalence estimation • Epidemiological modeling	Fundamental to understanding diagnostic disparities and testing biases

Visualization	Core Concept	Direct Health Applications	Relevance to Health Equity Research
Central Limit Theorem	Statistical sampling distributions	• Clinical trial design • Population health statistics • Biostatistical analysis • Quality control in laboratory testing	Critical for representative sampling in health disparity studies
Pathfinding Algorithms	Optimal path determination	• Protein folding pathways • Neural network connectivity analysis • Drug delivery route optimization • Surgical planning	Enables understanding of biological pathway analysis in personalized medicine
Pendulum Wave	Harmonic motion and phase relationships	• Cardiac rhythm analysis • Respiration mechanics • Physical therapy motion analysis • Medical device oscillatory systems	Illustrates biological rhythms and mechanical biomedical systems

Planned Health-Specific Visualizations

Proposed Visualization	Core Concept	Direct Health Applications	Relevance to AIM-AHEAD
Machine Learning Model Explainability	Transparent AI decision-making	• Feature importance in health predictions • Bias detection in clinical algorithms • Model interpretation for clinicians	Directly addresses algorithmic bias in healthcare AI

Proposed Visualization	Core Concept	Direct Health Applications	Relevance to AIM-AHEAD
Clustering Algorithms	Patient/data grouping methods	• Patient cohort identification • Disease subtype discovery • Genomic expression patterns • Social determinants clustering	Essential for precision medicine approaches to health disparities
Network Analysis	Relationship mapping in complex systems	• Disease transmission networks • Healthcare access mapping • Social determinant interconnections • Patient-provider relationships	Maps healthcare disparities within communities
Natural Language Processing	Text analysis fundamentals	• Medical record text mining • Clinical note interpretation • Sentiment analysis in patient feedback • Medical literature analysis	Helps address language and literacy barriers in healthcare
Survival Analysis	Time-to-event modeling	• Treatment effectiveness comparison • Disease progression prediction • Clinical trial outcomes analysis • Health disparity impact on outcomes	Critical for quantifying disparity effects on health outcomes

Proposed Visualization	Core Concept	Direct Health Applications	Relevance to AIM-AHEAD
Biomedical Image Processing	Medical image analysis techniques	• Image segmentation • Feature extraction • Tissue classification • Anomaly detection	Builds foundation for understanding AI imaging tools in diagnostic equity

Health-Specific Module Mockup: ECG Signal Processing

Module Description

The proposed **ECG Signal Analysis** visualization would demonstrate how Fourier transforms enable clinical interpretation of heart rhythms, highlighting applications to cardiac health disparities.

Key Components:

1. **Interactive ECG Signal Panel**
   - Real ECG signal examples from diverse populations
   - Ability to introduce various cardiac conditions (atrial fibrillation, myocardial infarction)
   - User-adjustable noise levels to simulate real-world recording conditions
2. **Frequency Domain Analysis**
   - Real-time decomposition of ECG into frequency components
   - Visualization of normal vs. abnormal frequency patterns
   - Highlighting of clinically significant frequency bands
3. **Demographic Comparison Tool**
   - Preloaded ECG patterns showing population variations
   - Explanation of how algorithmic bias in ECG interpretation affects different populations
   - Interactive elements demonstrating how algorithms trained on homogeneous data can misinterpret signals from diverse populations
4. **Clinical Decision Support Simulation**
   - Demonstration of how frequency analysis informs automated diagnostic suggestions
   - Exploration of threshold adjustments for different populations
   - Transparent visualization of confidence levels in diagnoses

Educational Approach

The module would guide users through:

- Basic ECG interpretation
- How frequency analysis reveals patterns invisible in time domain

- Why population-specific considerations matter in algorithm development
- How biased training data affects diagnostic accuracy for underrepresented groups

Educational Impact Metrics

Knowledge Acquisition Metrics

- **Pre/Post Conceptual Testing**: Validated assessment instruments measuring understanding of key concepts before and after module use
- **Retention Testing**: Follow-up assessment at 1-3 months to measure long-term knowledge retention
- **Application Exercises**: Practical problems requiring application of learned concepts to new scenarios
- **Confidence Surveys**: Self-reported comfort with concepts and willingness to engage with advanced topics

Engagement Metrics

- **Time on Task**: Duration and pattern of interaction with visualizations
- **Interaction Depth**: Number and variety of parameter adjustments made during exploration
- **Return Rate**: Frequency of return visits to the platform
- **Feature Utilization**: Usage patterns of different visualization components
- **Progression Tracking**: Movement from basic to advanced concepts within the platform

Diversity and Inclusion Metrics

- **Demographic Reach**: User diversity across racial, ethnic, gender, and geographical dimensions
- **Institutional Diversity**: Adoption across different types of institutions (HBCUs, tribal colleges, community colleges, R1 universities)
- **Accessibility Compliance**: WCAG 2.1 AA standards adherence
- **Multi-device Access**: Usage patterns across devices (addressing digital divide concerns)
- **Language Preference**: Utilization of multi-language support features

Outcomes-Based Metrics

- **Career Pathway Impact**: Tracking of users entering AI/ML research fields
- **Research Participation**: Integration into research training programs for underrepresented groups
- **Educational Persistence**: Correlation between platform usage and continuation in STEM education
- **Collaborative Projects**: Formation of cross-institutional research collaborations
- **Publication Outcomes**: Research outputs crediting platform for conceptual foundation

Implementation Timeline

- **Phase 1** (Months 1-3): Development of ECG Signal Processing and Machine Learning Explainability modules
- **Phase 2** (Months 4-6): Beta testing with diverse learner groups and curriculum integration
- **Phase 3** (Months 7-12): Expansion to additional modules and deployment of comprehensive evaluation system

This educational technology aligns perfectly with AIM-AHEAD's mission by providing accessible, engaging tools that build conceptual understanding of AI/ML fundamentals among diverse learners, directly addressing computational literacy barriers that limit participation in health equity research.