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Hybrid AI System for Heart Disease Detection Using Gemini

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ABSTRACT :

Heart-related conditions remain a leading global health challenge. This paper introduces a hybrid AI system leveraging Google's Gemini platform to detect heart disease using clinical records, medical imaging, and genomic data. The system aims to improve detection accuracy and provide explainable insights to support clinical decision-making, bridging the gap between advanced diagnostics and practical healthcare needs.

1. Introduction

Cardiovascular diseases (CVDs) significantly impact global health and healthcare systems. Traditional diagnostics often require expensive or invasive procedures, limiting accessibility. With AI's advancement—particularly in multimodal platforms like Gemini and Med-Gemini—there's a shift toward integrating diverse data types for more accurate and accessible diagnostics. This project explores such integration for heart disease detection.

2. Problem Statement

Despite technological progress, heart disease detection faces key challenges:

- Inaccessibility: High costs and resource requirements.
- Isolated Data Use: Disconnection between data types leads to incomplete diagnosis.
- Diagnostic Uncertainty: Misclassifications from current models may delay or misdirect treatment.
- Black-Box Models: Lack of transparency in AI decisions limits trust in clinical settings.

This study aims to develop an integrated and explainable AI system that is accurate, accessible, and trustworthy.

3. Objectives

- Design a heart disease detection system using Gemini's multimodal AI.
- Integrate clinical, imaging (ECGs, X-rays, retinal scans), and genomic data.
- Benchmark against existing models and methods.
- Implement explainability features for clinical transparency.
- Explore real-world applicability, including in low-resource settings.

4. Literature Review

Recent literature emphasizes AI in diagnostics:

- Gemini models perform well in multimodal data interpretation.
- AI has shown promise in predicting systemic diseases via retinal scans (Rajagopal, 2023).
- Genomic analysis (e.g., polygenic risk scores) enhances diagnostic potential.
- However, current systems lack interpretability and multimodal integration.

This project builds on these advancements for a more holistic and explainable diagnostic tool.

5. Proposed System

A hybrid AI architecture utilizing Gemini's capabilities is proposed. The workflow includes:

- Input of multimodal health data.
- Processing via fine-tuned Gemini models.
- Output: risk scores, heatmaps, and textual explanations.

By integrating multiple data sources, the model provides a comprehensive patient profile, improving diagnostic confidence.

6. Methodology and Implementation

6.1 Data Collection

Uses anonymized datasets, including:
- Clinical records (age, symptoms, test results).
- Medical imaging (ECGs, X-rays, retinal scans).
- Genomic data (polygenic markers).

6.2 Data Preparation

Data undergoes cleaning, normalization, and annotation. Ethical handling and anonymization are prioritized.

6.3 Model Training

The Gemini model is fine-tuned with an 80-10-10 train-validation-test split. Evaluated with:
- Accuracy
- Precision & Recall
- AUC-ROC

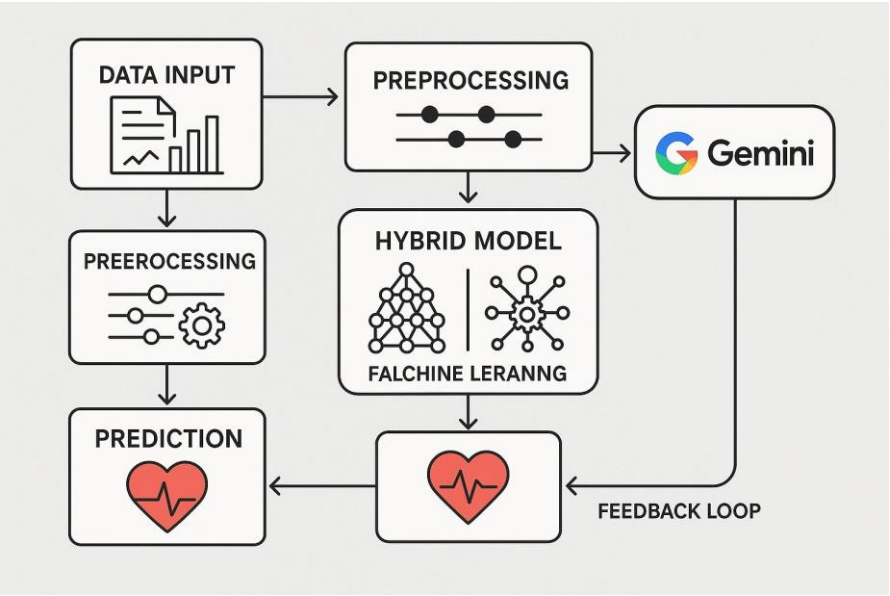
Cross-validation ensures performance stability.

6.4 Explainability Integration

Incorporates SHAP and Grad-CAM for decision transparency.

6.5 Prototype Development

A web interface allows clinicians to view predictions, risk levels, and explanation visuals, with options for feedback and iteration.



7. Results and Discussion

Early findings:

- Enhanced accuracy over single-modality systems.
- Clinician approval of explainability features.
- Genomic data boosts consistency.

Challenges:
- Variability in image/data quality.
- Limited access to comprehensive genomic data.
- Regulatory hurdles before clinical use.

8. Conclusion

The hybrid Gemini-based AI system improves heart disease detection by combining clinical, imaging, and genetic data with a focus on transparency. Future work will target larger datasets, real-time deployment, and broader clinical trials.

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