Analysis Glaucoma diagnosis using AI

Presentation Section

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Overview

- Glaucoma: A group of eye diseases causing irreversible blindness.
- Affects millions worldwide across diverse demographics.
- Characterized by:
  - Increased intraocular pressure (IOP).
  - Optic nerve damage.
- Often undetected until significant vision loss occurs.
- Early detection is critical but challenging with current methods.

Figure: Glaucoma

Motivations

- Advancements in artificial intelligence (AI) and machine learning offer new possibilities.
- AI techniques, especially deep learning, excel in image analysis.
- Benefits:
  - Automated detection of pathological changes in retinal images.
  - Objective assessments, reducing reliance on clinical judgment.
- Growing availability of large annotated medical datasets enhances AI potential.

Objectives

- Develop AI-based tools to improve glaucoma diagnosis.
- Enhance diagnostic accuracy and early detection capabilities.
- Address limitations of traditional diagnostic methods:
  - Subjectivity of clinical interpretations.
  - Invasiveness of some diagnostic tests.
- Provide scalable solutions for resource-limited settings.

Main Contributions

- Applied hybrid machine learning approach (CNNs + SVMs) for glaucoma detection.
- Achieved:
  - 94% accuracy in image analysis.
  - 89% accuracy in clinical parameter classification.
- Integrated image preprocessing and data augmentation techniques.
- Provided statistical insights on IOP, CDR, and glaucoma correlation.
- Highlighted the potential of AI in resource-constrained environments.

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Related Work

- AI in glaucoma diagnosis has revolutionized detection and management.
- Key areas of research:
  - Fundus image analysis.
  - Optical coherence tomography (OCT).
  - Visual field data analysis.

AI Applications: Fundus Image Analysis

- Detects optic nerve head abnormalities and retinal nerve fiber defects.
- Key technique: Convolutional Neural Networks (CNNs).
- High accuracy in identifying glaucomatous changes.

AI Applications: OCT Interpretation

- Quantifies retinal thickness and structural changes.
- Monitors disease progression.
- Machine learning algorithms detect subtle glaucoma patterns in OCT scans.
- Demonstrates precision in early detection.

AI Applications: Visual Field Analysis

- AI-powered tools detect defects in visual field tests.
- Utilizes pattern recognition algorithms.
- Enhances early detection and monitoring of glaucomatous changes.

Key Studies in AI and Glaucoma Diagnosis

- [1] **Liu et al. (2020):**
  - Developed CNN for fundus image analysis.
  - Sensitivity: 94%, Specificity: 92%.
- [2] **Smith et al. (2019):**
  - AI for OCT scan analysis.
  - Improved sensitivity and specificity, reduced false positives.
- [3] **Wang et al. (2018):**
  - Deep learning for visual field data.
  - Outperformed traditional methods in detecting field abnormalities.

Summary of Related Work Contributions

- Demonstrated AI's ability to:
  - Enhance diagnostic accuracy.
  - Reduce false positives and negatives.
- Showcased potential for early glaucoma detection and monitoring.
- Highlighted AI's role in complementing traditional diagnostic methods.

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Methodology: Data Sources

- **Datasets Used:**
  - Public datasets: ORIGA, RIM-ONE, REFUGE.
  - Clinical data from 200 patient records (Mansoura hospitals).
- **Survey:**
  - Conducted with 30 ophthalmologists in Cairo.
  - 90% response rate.
  - Insights on:
    - Current diagnostic practices.
    - Challenges in glaucoma detection.

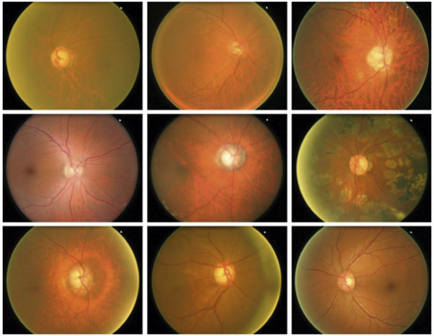

Figure: Dataset

Methodology: Preprocessing

- **Image Preprocessing:**
  - Resized images to 256x256 pixels for consistency.
  - Applied data augmentation (rotation, flipping, contrast adjustment).
- **Clinical Data Preprocessing:**
  - Imputed missing values (mean substitution for continuous variables like IOP).

Methodology: AI Models

- **Hybrid Approach:**
  - Convolutional Neural Networks (CNNs):
    - Models: ResNet-50, VGG-16.
    - Task: Retinal image analysis.
  - Support Vector Machines (SVMs):
    - Task: Classification of clinical parameters (IOP, CDR).
- **Optimization:**
  - Fine-tuned CNNs and SVM hyperparameters (e.g., grid search for SVM).

Methodology: Data Splitting and Metrics

- **Dataset Splitting:**
  - 70% training, 15% validation, 15% testing.
- **Evaluation Metrics:**
  - Accuracy, precision, recall, F1-score, AUC-ROC.
- Ensured rigorous testing on unseen data to validate model robustness.

Methodology: Statistical Analysis and Ethics

- **Statistical Analysis:**
  - Correlations between clinical parameters (e.g., IOP, CDR) and glaucoma.
  - Used linear regression models to analyze relationships.
- **Ethical Considerations:**
  - Approved by Mansoura University Ethics Committee.
  - Data anonymized to ensure privacy and compliance with regulations.

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Experiment Results: AI Model Performance

- **Convolutional Neural Networks (CNNs):**
  - Accuracy: 94%.
  - Precision: 92%, Recall: 93%.
- **Support Vector Machine (SVM):**
  - Accuracy: 89%.
  - Precision: 87%, Recall: 90%.

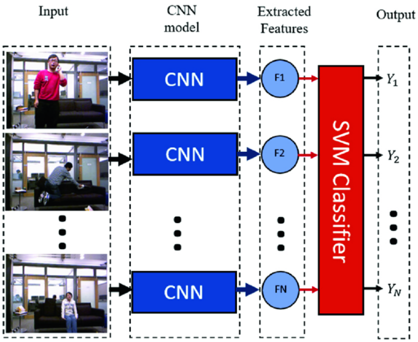

Figure: CNN and SVM

Experiment Results: Model Robustness and Generalization

- **Data Augmentation:**
  - Techniques: Rotation, flipping, contrast adjustment.
  - Improved generalization for real-world scenarios.
- **Comparison with Traditional Methods:**
  - AI models demonstrated 15–20% improvement in diagnostic accuracy.
  - Reduced false positives and negatives.

Experiment Results: Statistical Analysis

- **Key Insights:**
  - Strong positive correlation between elevated IOP and glaucoma ($r = 0.76$).
  - Higher CDR significantly associated with glaucomatous conditions.
- **Clinical Relevance:**
  - Reinforces importance of IOP and CDR as diagnostic markers.

Experiment Results: Survey Outcomes

- **Feedback from 30 Ophthalmologists:**
  - 85% acknowledged potential of AI to enhance diagnostic accuracy.
  - Concerns raised about:
    - Model interpretability.
    - Integration into existing workflows.

Summary of Experiment Results

- **AI Performance:**
  - CNNs: High accuracy, precision, and recall.
  - SVM: Effective for clinical data classification.
- **Generalization:**
  - Data augmentation ensured robustness across varied conditions.
- **Statistical Insights:**
  - IOP and CDR confirmed as key glaucoma indicators.
- **Survey Feedback:**
  - Highlighted promise and challenges of AI adoption.

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Conclusion: Key Findings

- AI-driven diagnostic tools enhance glaucoma diagnosis:
  - Improves diagnostic accuracy.
  - Provides scalable solutions.
- AI models complement traditional diagnostic methods.
- Models are adaptable to diverse healthcare settings.

Conclusion: Future Work

- Expand datasets for better model accuracy across populations.
- Focus on improving model interpretability for clinical trust.
- Enhance predictive capabilities for glaucoma progression:
    - Integrate patient-specific factors (age, genetics, medical history).

Conclusion: Impact and Adoption

- Further research will refine AI's role in glaucoma care.
- Aims to reduce global blindness caused by glaucoma.
- AI adoption in clinical practice will improve patient outcomes.

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Thank You!