**Early Detection of Diabetic Retinopathy Using a Compact, Data-Efficient AI Model**

**Core Keywords**

* **Diabetic Retinopathy (DR)**
* **Early Detection / Early Diagnosis**
* **Artificial Intelligence (AI)**
* **Deep Learning / Machine Learning**
* **Compact AI Models**
* **Data-Efficient Models**

**Supporting Keywords**

* **Retinal Imaging / Fundus Photography / OCT**
* **Medical Image Analysis**
* **Feature Extraction**
* **Transfer Learning**
* **Few-shot / Low-data learning**
* **Lightweight Neural Networks (e.g., MobileNet, EfficientNet-lite)**
* **Explainable AI (XAI) in healthcare**
* **Clinical Screening / Automated Diagnosis**
* **Sensitivity & Specificity**
* **Resource-constrained environments (low-computation models)**

**Useful keywords (for searching databases)**

* **"Early detection of diabetic retinopathy with AI"**
* **"Lightweight deep learning model for retinal disease"**
* **"Data-efficient neural networks in medical imaging"**
* **"Compact AI architecture for diabetic retinopathy screening"**
* **"Transfer learning for fundus image analysis"**
* **"Low-resource deep learning in healthcare"**

**Keyword map for each section of the article**

**Abstract**

* Keywords: *early detection, diabetic retinopathy, compact AI model, data-efficient learning, clinical relevance, lightweight deployment*

**Introduction**

* Keywords: *diabetic retinopathy, leading cause of blindness, early screening, limitations of traditional approaches, AI-based diagnosis, lightweight models*
* منابع: مقالات پزشکی (Ophthalmology, Diabetes Care) + مروری‌های AI در پزشکی.

**Related Work**

* **AI in medical imaging** → *deep learning, CNN, transfer learning, clinical adoption*
* **Retinal image analysis methods** → *fundus photography, OCT, segmentation, lesion detection*
* **Lightweight and data-efficient models** → *MobileNet, EfficientNet-lite, pruning, quantization, distillation*
* **Reporting standards** → *CONSORT-AI, SPIRIT-AI, guidelines for ML in healthcare*

**Methods**

* **Data and Ethics**
  + Keywords: *fundus datasets (e.g., EyePACS, Messidor), data privacy, ethics approval*
* **Preprocessing**
  + *image normalization, data augmentation, class imbalance handling, image quality filtering*
* **Model Design**
  + *compact backbone, knowledge distillation, device constraints, computational efficiency*
* **Data-Efficient Learning Strategy**
  + *few-shot learning, semi-supervised methods, transfer learning, calibration, domain adaptation*
* **Training Protocol**
  + *loss functions (cross-entropy, focal loss), hyperparameter tuning, reproducibility*

**Results**

* **Metrics** → *AUROC, sensitivity, specificity, AUPRC, F1-score, calibration*
* **Robustness & validation** → *external datasets, cross-dataset generalization*
* **Ablation studies** → *effect of distillation, effect of preprocessing, effect of augmentation*
* **Deployment** → *model compression, latency, inference time, mobile device performance*

**Discussion**

* Keywords: *comparison with state-of-the-art, clinical implications, limitations, deployment in low-resource settings, explainability*

**Conclusion**

* Keywords: *screening and triage, public health, compact AI deployment, future outlook*