Report on the Fast and Fully Automated System for Glaucoma Detection.

1. Executive Summary: This report summarizes a project that developed a low-computationally intensive and memory-efficient system for the automated detection of glaucoma from color fundus photographs. Glaucoma is a leading cause of irreversible blindness worldwide, and early, accessible screening is critical. The developed system employs a two-step deep learning pipeline that first isolates the optic nerve head (ONH) region using a simplified YOLO architecture and then classifies it using a MobileNetV3Small model. The system achieved an accuracy of 97.4% , with performance comparable to more resource-intensive models while requiring 12 times less memory than standard architectures like ResNet50. This high efficiency makes the system ideal for deployment on resource-limited hardware, such as portable fundus cameras.

2. Project Objective: The primary objective of this project was to design and validate a fast, fully automated, and computationally lightweight system for glaucoma detection. Traditional manual assessment of the optic nerve head is time-consuming and subjective. While many existing deep learning solutions have high accuracy, they are often computationally intensive and require manual cropping of the region of interest, making them difficult to integrate into portable screening devices. This project aimed to overcome these limitations by creating a system that is both highly accurate and efficient enough to run on resource-limited devices, facilitating wider and more accessible early screening.

3. Methodology: The system's methodology is a two-step process designed for efficiency and accuracy:

- **Step 1: Optic Nerve Head (ONH) Detection:** The system first processes a full color fundus photograph to automatically identify and crop the ONH region. This is accomplished using a simplified version of the You Only Look Once (YOLO) Nano architecture. By isolating the ONH, the system ensures the subsequent classification model focuses only on the most clinically relevant area, which improves the CNN's learning capacity and performance.
- **Step 2: Glaucoma Classification:** The cropped ONH region is then passed to a separate, independently trained classification model. After extensive experiments with seven different state-of-the-art CNNs, the MobileNetV3Small architecture was selected as the optimal classifier. The model was trained using a transfer learning approach, which initializes the model with pre-trained weights from the ImageNet dataset to improve performance and reduce training time.

4. Technology and Implementation:

- **Software and Frameworks:** The system was developed using Python (version 3.8.12). The classification models were implemented in Keras (version 2.4.3) with a TensorFlow (version 2.3.0) backend. The YOLO models used for object detection were implemented in PyTorch (version 2.0.0).

- **Hardware:** All training and validation were performed on a Dell Precision 5820 Tower Workstation equipped with an Intel Xeon 3.60 GHz CPU, 64 GB RAM, and an NVIDIA GeForce RTX 2080Ti GPU.
- **Dataset:** The models were trained and validated on a comprehensive collection of 6,671 fundus images sourced from seven publicly available datasets.

5. Performance and Results: The proposed system, using the simplified YOLO net and MobileNetV3Small, demonstrated high performance and efficiency:

- **Accuracy:** 97.4%
- **Sensitivity:** 97.5%
- **Specificity:** 97.2%
- **F1 Score:** 97.3%
- **Area Under the Curve (AUC):** 99.3%
- **Efficiency:** The system is significantly more efficient than traditional deep learning models. It requires 12 times less memory than ResNet50 and produces decisions 2 times faster.

6. Conclusion: This project successfully developed and validated a fast, fully automated, and memory-efficient system for glaucoma detection. The system's performance is comparable to, or better than, highly computationally intensive state-of-the-art CNNs. By drastically minimizing resource requirements, the proposed solution is well-suited for direct integration into portable, resource-limited screening devices. This work represents a significant step towards making early, accurate glaucoma diagnosis more accessible worldwide.

7. Reference: Saha, S., Vignarajan, J. & Frost, S. A fast and fully automated system for glaucoma detection using color fundus photographs. *Scientific Reports* **13**, 18408 (2023). https://doi.org/10.1038/s41598-023-44473-0