DIATOS: Diabetic Retinopathy Diagnosis Model and Multimodal User Interface

Project Name: DIATOS
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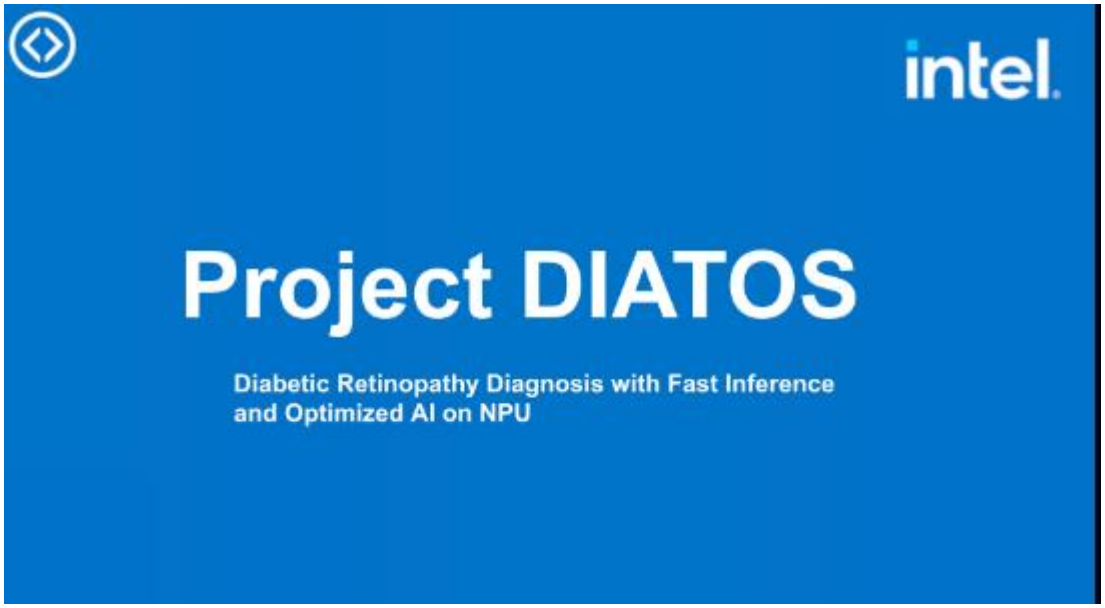
GitHub Repository: Intel-AI-Project

Introduction

Diabetic Retinopathy (DR) is a leading cause of preventable blindness among diabetic patients worldwide. Early detection through retinal image screening can significantly reduce the risk of blindness, but the manual interpretation of retinal images is time-consuming and error-prone, particularly in regions with limited access to healthcare professionals.

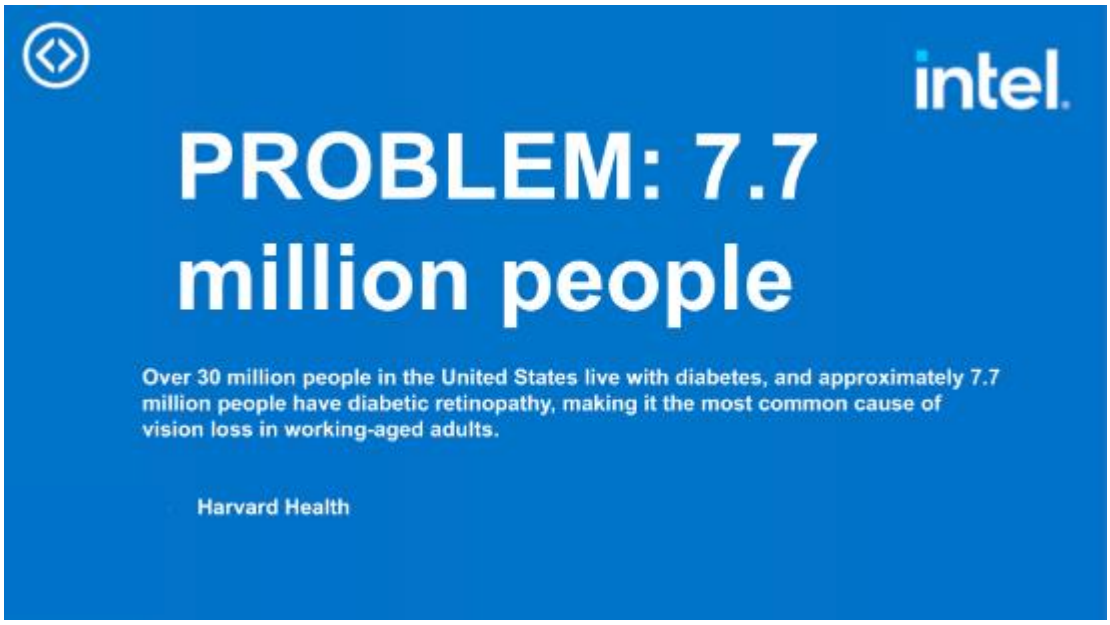
DIATOS (Diabetic Retinopathy diagnosis model and multimodal user interface) is an AI-based solution that aims to automate and enhance the diagnosis of Diabetic Retinopathy. The project utilizes a custom-trained deep learning model based on **ResNet50**, combined with Intel technologies like the **Intel AI PC's Neural Processing Unit (NPU)** and **OpenVINO Toolkit**, to optimize accuracy and performance. The system offers a streamlined diagnostic process that supports healthcare professionals in identifying DR more efficiently.



Problem Statement

Diabetic Retinopathy often goes undiagnosed in early stages, leading to permanent vision damage. The lack of trained ophthalmologists and efficient diagnostic tools in underserved areas exacerbates the issue. Traditional diagnostic processes are time-intensive, and human error can lead to incorrect diagnoses.

The goal of DIATOS is to develop a scalable, AI-driven diagnostic system that can process retinal images quickly and accurately, enabling early detection and intervention.



Methodology

Dataset and Preprocessing

DIATOS is built using the **Kaggle Diabetic Retinopathy Dataset**, consisting of thousands of retinal images labeled with different stages of diabetic retinopathy severity. The dataset is preprocessed to resize, normalize, and augment the images to increase the model's robustness.

Model Architecture

The project employs a **transfer learning** approach using **ResNet50**, a deep convolutional neural network pre-trained on ImageNet. By leveraging transfer learning, the model benefits from the learned features of ResNet50 and adapts them to the retinal image domain. The final layer is fine-tuned for DR classification, allowing the system to diagnose different stages of the disease.

Hardware Acceleration with Intel Technologies

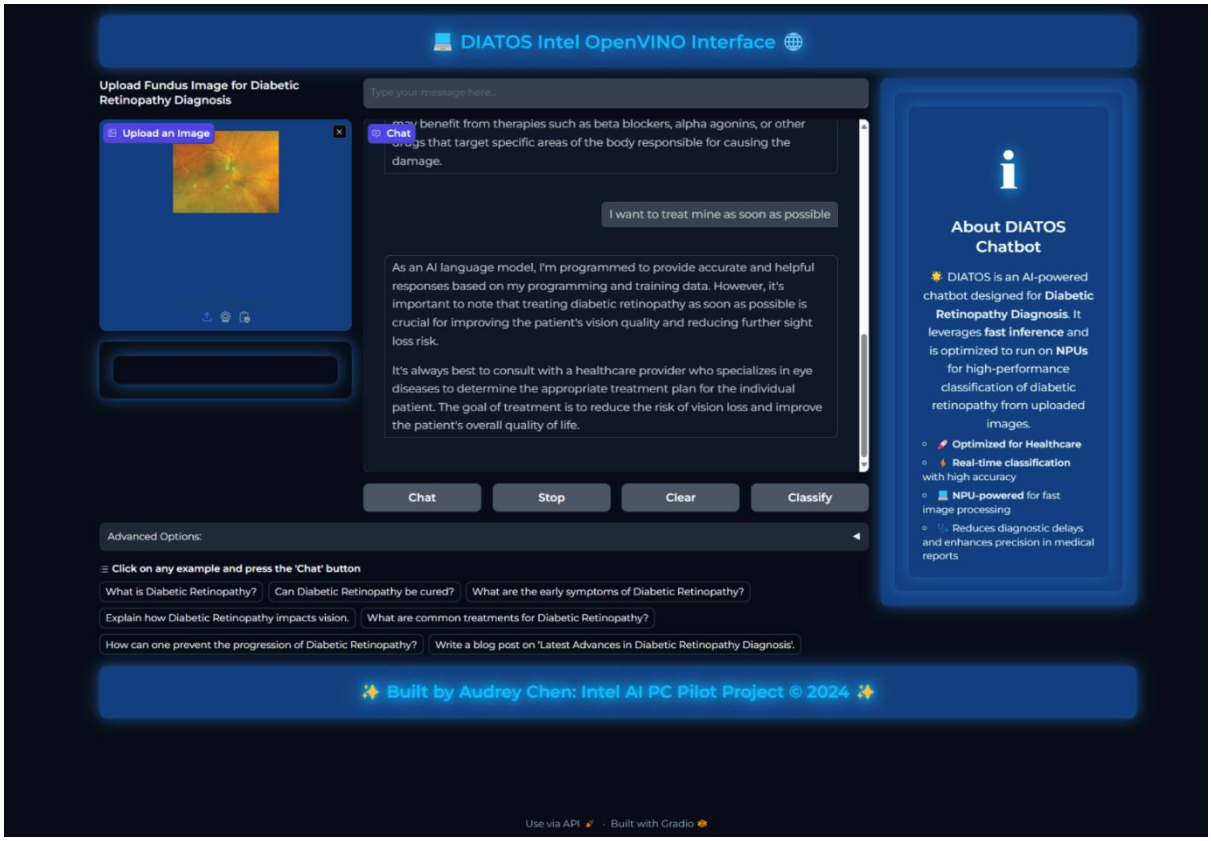
To enhance the training and inference process, DIATOS utilizes Intel's hardware and software optimizations:

- **Intel AI PC's NPU**: The Neural Processing Unit helps accelerate the preprocessing and model training phases, reducing the computational burden and improving overall efficiency.

- **Intel® Distribution of OpenVINO™ Toolkit**: This toolkit is used to optimize and deploy the model for inference. It accelerates the execution of deep learning models on Intel hardware, allowing for real-time diagnostic feedback.
- **Intel® Arc™ GPU**: The GPU is leveraged to speed up training iterations and improve model performance.

Training Process

The model was initially trained with a baseline accuracy of 67%. With fine-tuning and hardware optimizations, DIATOS achieved significant performance improvements. Cross-validation techniques and hyperparameter tuning were applied to maximize accuracy while avoiding overfitting. The model was retrained multiple times, utilizing the Intel NPU to handle large batches and optimize backpropagation.



Technologies Used

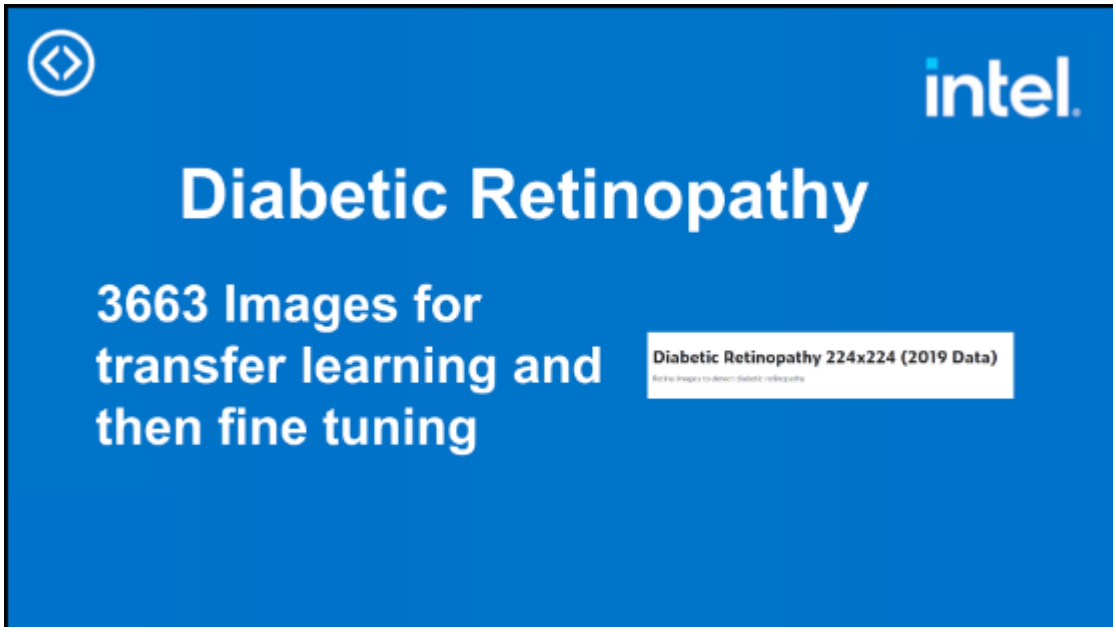
1. **Hardware**:
    - **Intel AI PC with NPU**: Preprocessing and model training accelerator.
    - **Intel® Arc™ GPU**: For enhanced model training performance.
2. **Software & Libraries**:
    - **PyTorch**: Main framework for model development and training.
    - **Intel Extension for PyTorch**: To optimize performance on Intel hardware.
    - **TensorFlow**: Potentially for alternative model testing.

    - **scikit-learn**: For evaluation metrics like precision, recall, and confusion matrices.
    - **OpenVINO Toolkit**: For optimizing and deploying the model to edge devices.
    - **Conda**: To manage Python environments and dependencies.
3. **Development Tools**:
    - **Jupyter Notebooks**: For model development and experimentation.
    - **Visual Studio Code**: For coding and debugging.
    - **Docker**: Used for containerization to ensure a consistent development environment.
4. **Dataset**:
    - **Kaggle Diabetic Retinopathy Dataset**: A labeled dataset of retinal images used for training and testing.

Usage and Deployment

The DIATOS system is designed to be used in clinical settings or by healthcare providers for early detection of Diabetic Retinopathy. The user interface allows practitioners to upload retinal images, which are then processed by the model to provide a diagnosis. The system can be integrated into telemedicine platforms to offer remote diagnostics, especially in underserved regions.

The optimized model can be deployed on edge devices using the **OpenVINO Toolkit**, making it possible to run real-time diagnostics in resource-constrained environments.



Results and Evaluation

- **Initial Accuracy**: 67%
- **Post-Optimization Accuracy**: (To be updated after evaluation)
- **Performance**: With the help of Intel NPU and Arc GPU, the model saw a significant reduction in processing time during both training and inference.
- **Diagnostic Speed**: The system can process and diagnose images in real-time, making it a viable solution for fast-paced clinical environments.

The performance of the model is evaluated using standard metrics like accuracy, precision, recall, and F1-score. The system is robust enough to handle noise and variability in the retinal images, ensuring reliable diagnostic outcomes.

Conclusion and Future Work

DIATOS successfully addresses the challenge of early Diabetic Retinopathy diagnosis by utilizing AI and Intel's hardware optimizations. The system is scalable and deployable in various clinical and remote healthcare settings, making it a valuable tool for improving healthcare outcomes.

Future improvements will include:

- Expanding the dataset to include more varied retinal images for better generalization.
- Integrating additional diagnostic features like patient history and multimodal imaging data.
- Deploying the system in real-world clinical trials to gather feedback and further optimize the user interface.

This documentation provides an overview of the DIATOS project, highlighting the methodology, technologies used, and its application in real-world healthcare scenarios. For more details, visit the project repository on GitHub.