Solution Architecture: HematoVision - Advanced Blood Cell Classification

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Project Name	Hematovision: advanced blood cell classification using transfer learning
Maximum Marks	4 marks

1. Introduction

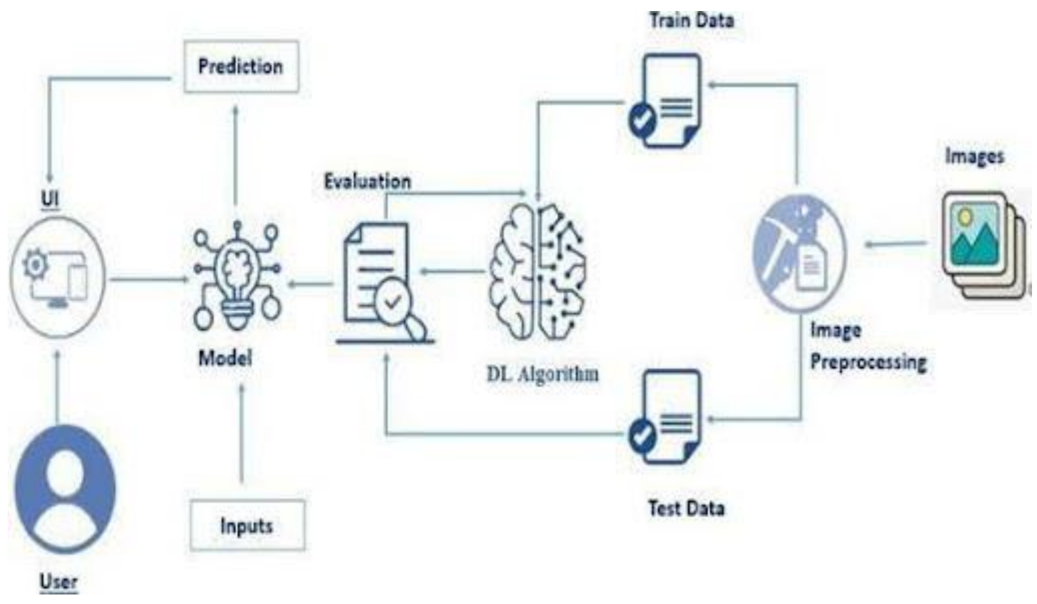
This document outlines the solution architecture for HematoVision, an AI-powered system designed for the accurate and efficient classification of blood cells. The architecture leverages a combination of deep learning models and a user-friendly web application to provide a robust and scalable solution for pathologists and healthcare professionals.

2. High-Level Architecture Overview

The HematoVision system follows a typical client-server architecture, where a web-based frontend interacts with a Python-based backend that hosts the machine learning model.
The core components include:

- **Client-Side (Web Browser):** User interface for interacting with the system.

- **Web Application Backend (Flask):** Handles user requests, manages image uploads, and orchestrates interactions with the machine learning model.
- **Machine Learning Model (TensorFlow/Keras):** The trained deep learning model responsible for blood cell classification.
- **Storage:** For temporary storage of uploaded images.



3. Detailed Component Breakdown

3.1. Client-Side (Frontend)

- **Technology:** HTML, CSS, JavaScript (standard web technologies).
- **Purpose:** Provides the graphical user interface (GUI) for users to interact with the HematoVision system.
- **Key Functions:**

- **Image Upload:** Allows users to select and upload blood cell images (e.g., `home.html`).
- **Display Results:** Presents the classification prediction and the uploaded image (e.g., `result.html`).
- **User Feedback:** Potentially provides visual cues for upload progress or errors.

3.2. Web Application Backend (Flask)

- **Technology:** Python, Flask framework (`app.py`).
- **Purpose:** Acts as the central hub, receiving requests from the frontend, processing them, and returning responses. It integrates the machine learning model.
- **Key Functions:**
- **API Endpoints:** Defines routes for image upload (`/predict`) and serving web pages (`/`).
- **Image Handling:** Receives uploaded image files, saves them temporarily, and prepares them for model inference.
- **Model Inference Orchestration:** Loads the pre-trained `blood_cell.h5` model and passes the processed image data to it for classification.
- **Result Processing:** Receives the prediction from the model and formats it for display on the frontend.
- **Error Handling:** Manages invalid file types or other processing errors.
- **Templating:** Renders HTML templates (`home.html` , `result.html`) to serve dynamic content to the user.

3.3. Machine Learning Model

- **Technology:** TensorFlow, Keras, MobileNetV2 (`model.ipynb` , `blood_cell.h5`).
- **Purpose:** The core intelligence of the system, responsible for accurately classifying blood cells.
- **Key Functions:**
- **Image Classification:** Takes a preprocessed blood cell image as input and outputs a probability distribution over the four blood cell classes (Eosinophil, Lymphocyte, Monocyte, Neutrophil).
- **Feature Extraction:** The pre-trained MobileNetV2 acts as a powerful feature extractor.
- **Prediction:** Provides the final predicted class based on the model's output.
- **Training Details (from `model.ipynb` and `README_HematoVision.md`):**
- **Architecture:** MobileNetV2 (pre-trained) with custom classification layers.
- **Dataset:** 12,500 augmented blood cell images from Kaggle.
- **Training:** 5 epochs (as per README), Adam optimizer, categorical cross-entropy loss.
- **Accuracy:** Approximately 85.3% validation accuracy.
- **Model Persistence:** The trained model is saved as `blood_cell.h5` for deployment.

3.4. Storage

- **Technology:** Local filesystem.
- **Purpose:** Temporarily stores uploaded images before they are processed by the model.
- **Key Functions:**

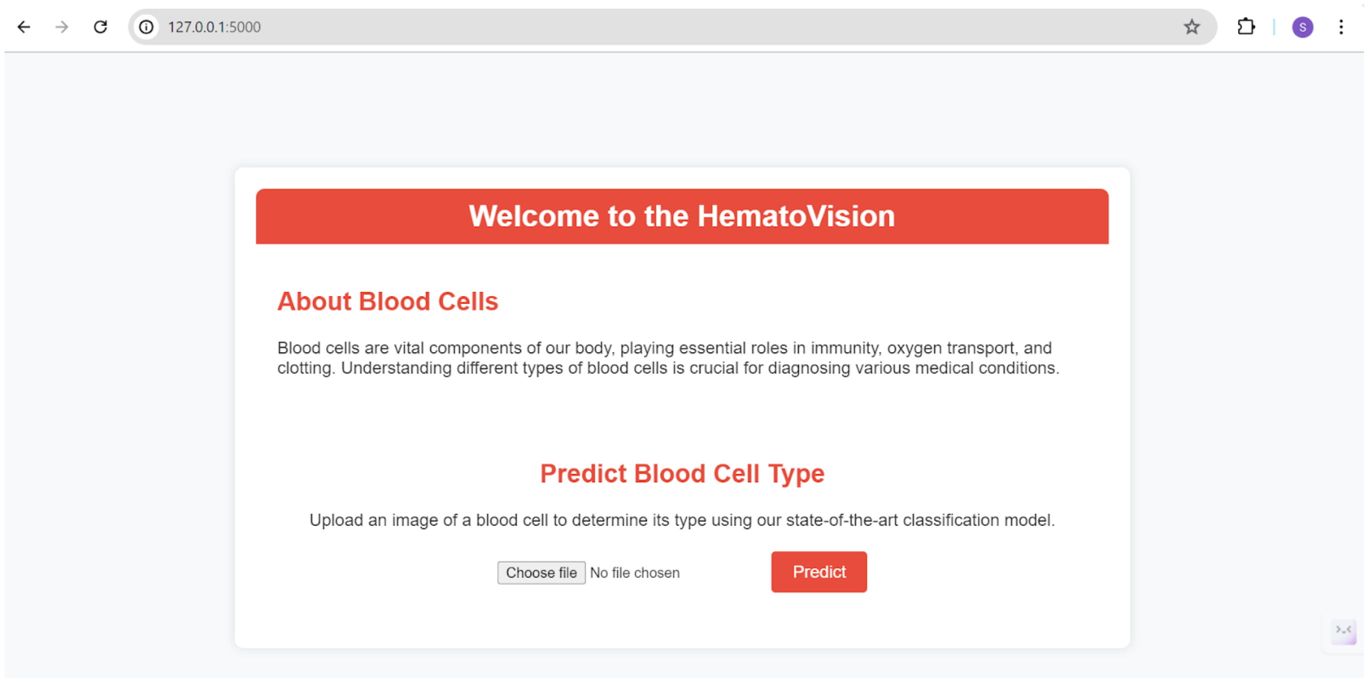
- **Temporary Uploads:** The static/uploads/ directory is used to store images uploaded by users via the web interface.

- **File Management:** Images are typically deleted after processing or after a certain period to manage storage space.

4. Data Flow and Interactions

1. **User Interaction:** A user accesses the HematoVision web application through their browser, which loads home.html from the Flask backend.
2. **Image Upload:** The user selects a blood cell image and uploads it via the web form.
   This HTTP POST request is sent to the /predict endpoint of the Flask application.
3. **Backend Processing:**
   - The Flask application (app.py) receives the uploaded image.
   - It saves the image temporarily in the static/uploads/ directory.
   - The image is then preprocessed (resized, normalized) to match the input requirements of the MobileNetV2 model.
   - The preprocessed image is passed to the loaded blood_cell.h5 model for inference.
4. **Model Prediction:** The MobileNetV2 model performs the classification and returns the predicted blood cell type.
5. **Result Display:**
   - The Flask application receives the prediction from the model.
   - It then renders the result.html template, passing the prediction and the path to the uploaded image.

- The result.html page is sent back to the user's browser, displaying the classification outcome.



Welcome to the HematoVision

About Blood Cells

Blood cells are vital components of our body, playing essential roles in immunity, oxygen transport, and clotting. Understanding different types of blood cells is crucial for diagnosing various medical conditions.

Predict Blood Cell Type

Upload an image of a blood cell to determine its type using our state-of-the-art classification model.

5. Deployment Considerations

- **Containerization:** The application can be containerized using Docker for consistent deployment across different environments.
- **Cloud Platforms:** Suitable for deployment on cloud platforms like Render, Railway, or Heroku, as indicated in README_HematoVision.md .
- **Scalability:** For high traffic, the Flask application can be scaled horizontally, and the model inference can be offloaded to dedicated GPU-enabled services.
- **Security:** Implement secure coding practices, input validation, and secure handling of uploaded files.

6. Future Enhancements

- **API for Integration:** Develop a dedicated API for external systems to integrate with the classification service.
- **Batch Processing:** Allow for the upload and classification of multiple images simultaneously.
- **Confidence Scores:** Display confidence levels for predictions to aid pathologists in decision-making.
- **Database Integration:** Store classification results and metadata in a database for auditing and analysis.
- **User Authentication:** Implement user login and role-based access control for secure access.