Solution Architecture: HematoVision - Advanced Blood Cell Classification

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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.

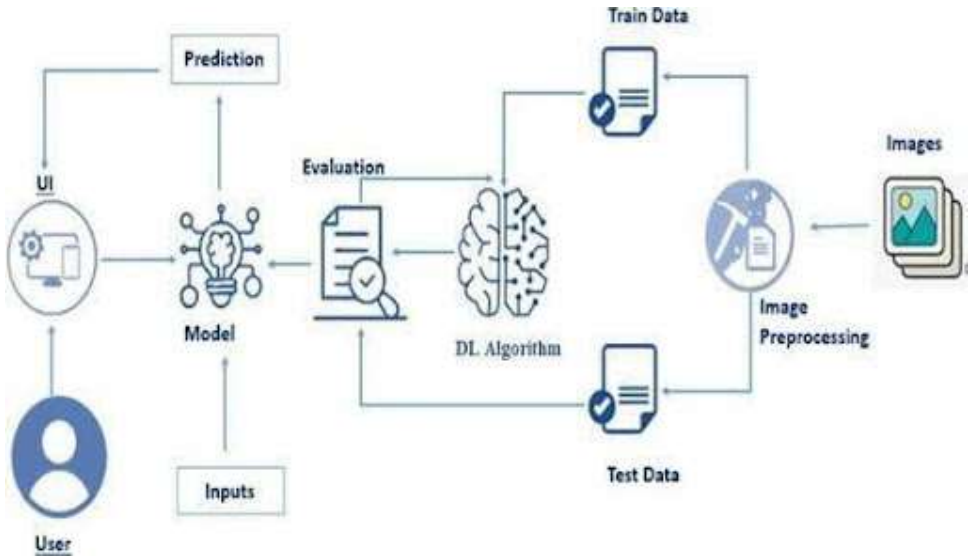
2. High-Level Architecture Overview

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.

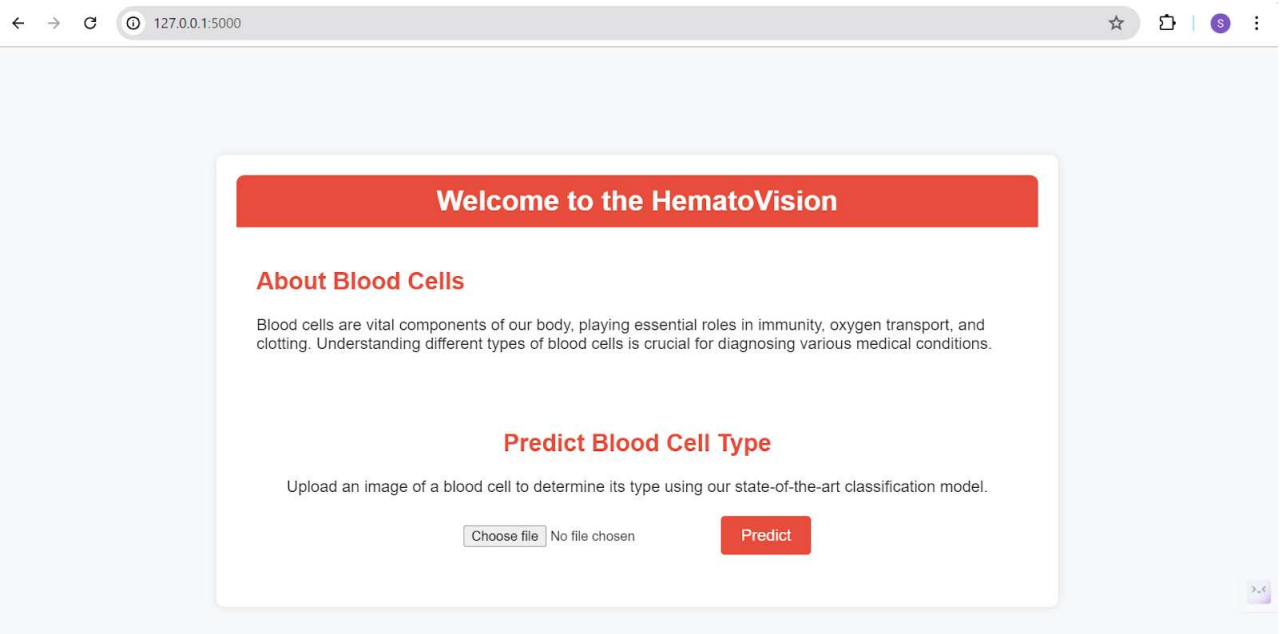
- **Key Functions:**

- **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.



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.