

# PROJECT SYNOPSIS

**Title:** AI-Powered Plant Disease Detection System

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## 1. Abstract

Plant diseases pose a significant threat to agricultural productivity, often resulting in substantial economic losses due to delays in identification and treatment. This project proposes a comprehensive solution that utilizes Generative AI to analyze plant images and detect diseases with high accuracy and speed. The system is built upon a robust, modern client-server architecture that ensures reliability and scalability. The application integrates a responsive React frontend with a high-performance FastAPI backend, utilizing the Google Gemini 2.0 Flash model to act as an expert plant pathologist. Key capabilities include real-time severity assessment, symptom identification, and an intelligent multi-language support system that provides both text and speech outputs in seven Indian languages.

## 2. Introduction

In the realm of modern agriculture, the timely identification of plant diseases is a critical factor in preventing crop loss and ensuring global food security. The Plant Disease Detection System is an advanced, AI-powered full-stack web application conceived to democratize access to plant pathology expertise. By leveraging Google's state-of-the-art Gemini AI technology, the system enables a wide range of users—from professional farmers and agricultural extension workers to home gardeners and students to instantly identify plant diseases through simple image analysis.

## 3. Objectives

The primary goal of this project is to develop a responsive and accessible tool for plant disease diagnosis. Specific objectives include:

- **Instant Detection:** To enable real-time analysis of plant images uploaded by users or captured via camera.
- **Actionable Insights:** To provide detailed reports including disease names, confidence scores, severity levels (Mild/Moderate/Severe), symptoms, and treatment plans.
- **Accessibility:** To break language barriers by offering analysis and text-to-speech (TTS) features in English, Hindi, Kannada, Tamil, Telugu, Marathi, and Gujarati.
- **Performance:** To ensure low-latency responses using optimized caching strategies for audio and analysis results.

## 4. Proposed System

The system follows a modern client-server architecture:

- **User Interface (Frontend):** Developed using **React.js** and **TailwindCSS**, the frontend provides a mobile-first interface where users can upload images or use a live camera feed. It handles user interactions, displays results, and manages audio playback for the TTS feature.
- **Backend Processing:** A **FastAPI** (Python) server handles API requests. It processes images (Base64 encoded) and sends them to the **Google Gemini AI** model for analysis.
- **AI Analysis:** The system uses the gemini-2.0-flash model to act as an expert plant pathologist, returning structured JSON data containing the diagnosis and care advice.
- **Storage & Caching:** **MongoDB** is used to store analysis history and system status logs. The system also implements an in-memory cache for TTS (Text-to-Speech) audio to ensure instant playback for repeated requests.

## 5. Technology Stack

The project utilizes a comprehensive set of modern technologies:

- **Frontend:**
  - **React (v18+):** For building a dynamic and responsive UI.
  - **TailwindCSS & Shadcn/ui:** For modern styling and UI components.
  - **Lucide React:** For consistent iconography.
- **Backend:**
  - **FastAPI:** A high-performance Python web framework for building APIs.
  - **Google Gemini AI:** For generative image analysis and disease prediction.
  - **gTTS (Google Text-to-Speech):** For converting analysis text into speech.
  - **Motor (AsyncIOMotorClient):** For asynchronous MongoDB database interactions.
- **Database:**
  - **MongoDB:** A NoSQL database for flexible data storage.

## 6. Key Features

- **Advanced Disease Detection:** accurately identifies plant diseases and assesses their severity (Healthy, Mild, Moderate, Severe) using Gemini AI.
- **Multi-Language Support:** instantly translates analysis results into 7 languages: English, Hindi, Kannada, Tamil, Telugu, Marathi, and Gujarati.
- **Intelligent Text-to-Speech:** Features an optimized TTS engine that reads out the diagnosis in the user's selected language, using caching to reduce latency to under 500ms for repeated requests.
- **Dual Input Modes:** Supports both file uploads (JPG/PNG) and live camera capture directly from the browser.
- **Comprehensive Care Guides:** Automatically generates symptoms lists, treatment recommendations, and prevention tips for every diagnosis.

## 7. Applications

- **Agriculture:** empowers farmers to quickly diagnose crop issues in the field without waiting for expert consultation.
- **Home Gardening:** Assists hobbyists in maintaining the health of indoor and outdoor plants.
- **Education:** serves as a practical learning tool for agricultural students to recognize various plant pathologies.
- **Remote Advisory:** Can be used by agricultural extension workers to provide instant advice in remote areas with limited connectivity.

## 8. Conclusion

The Plant Disease Detection System successfully integrates the power of Generative AI with a thoughtful, user-centric design to address a critical and widespread need in agriculture. By providing instant, accurate, and accessible plant health analysis, the platform empowers users to take proactive and informed steps in crop protection. The strategic inclusion of multi-language support and text-to-speech functionality ensures that this advanced technology is inclusive, reaching a diverse user base across different linguistic backgrounds. Ultimately, this project stands as a valuable tool for promoting sustainable plant care and enhancing agricultural resilience through technology.