**Maize Disease Detection System - Requirements & Process Flow**

**Project Overview**

AI-powered image classification system for identifying maize leaf diseases in Zimbabwe, targeting Common Rust, Gray Leaf Spot, Blight, and Healthy leaves.

**1. FUNCTIONAL REQUIREMENTS**

**1.1 Core Image Classification**

* **FR1.1**: System shall classify maize leaf images into exactly four categories: Common Rust, Gray Leaf Spot, Blight, and Healthy
* **FR1.2**: System shall accept standard image formats (JPEG, PNG, TIFF) with minimum resolution of 224x224 pixels
* **FR1.3**: System shall provide confidence scores for each classification result (0-100%)
* **FR1.4**: System shall handle batch processing of multiple images simultaneously
* **FR1.5**: System shall support real-time image capture from mobile device cameras

**1.2 User Interface & Interaction**

* **FR2.1**: System shall provide intuitive mobile application interface in English and Shona
* **FR2.2**: System shall allow users to capture images directly through camera or upload from gallery
* **FR2.3**: System shall display classification results with visual indicators and disease descriptions
* **FR2.4**: System shall provide treatment recommendations for identified diseases
* **FR2.5**: System shall maintain history of previous diagnoses for each user

**1.3 Data Management**

* **FR3.1**: System shall store user diagnosis history locally on device
* **FR3.2**: System shall support optional cloud sync for backup and analytics
* **FR3.3**: System shall collect anonymous usage statistics for model improvement
* **FR3.4**: System shall support offline model updates when internet is available

**1.4 Reporting & Analytics**

* **FR4.1**: System shall generate individual farm reports showing disease trends
* **FR4.2**: System shall provide aggregated regional disease prevalence data
* **FR4.3**: System shall export diagnosis data in CSV format for further analysis
* **FR4.4**: System shall integrate with agricultural extension services for reporting

**1.5 Educational Content**

* **FR5.1**: System shall provide disease identification guides with symptom descriptions
* **FR5.2**: System shall offer prevention and treatment recommendations
* **FR5.3**: System shall include seasonal disease risk calendars
* **FR5.4**: System shall provide contact information for local agricultural extension officers

**2. NON-FUNCTIONAL REQUIREMENTS**

**2.1 Performance Requirements**

* **NFR1.1**: Classification accuracy shall be ≥95% on test dataset
* **NFR1.2**: Image processing time shall be ≤3 seconds per image on mobile devices
* **NFR1.3**: Application startup time shall be ≤5 seconds
* **NFR1.4**: System shall handle concurrent usage by 10,000+ users
* **NFR1.5**: Model inference shall work offline without internet connectivity

**2.2 Scalability Requirements**

* **NFR2.1**: System architecture shall support horizontal scaling for web services
* **NFR2.2**: Database shall handle 1M+ image classifications per day
* **NFR2.3**: Model shall be updateable without requiring app reinstallation
* **NFR2.4**: System shall support deployment across multiple regions

**2.3 Reliability & Availability**

* **NFR3.1**: Mobile application shall have 99.5% uptime for offline functionality
* **NFR3.2**: Cloud services shall maintain 99.9% availability
* **NFR3.3**: System shall gracefully handle poor image quality inputs
* **NFR3.4**: Data backup and recovery processes shall be automated

**2.4 Security Requirements**

* **NFR4.1**: User data shall be encrypted at rest and in transit
* **NFR4.2**: System shall comply with data protection regulations
* **NFR4.3**: Authentication shall be implemented for administrative functions
* **NFR4.4**: Image data shall be anonymized before cloud storage

**2.5 Usability Requirements**

* **NFR5.1**: Application shall be usable by farmers with basic smartphone literacy
* **NFR5.2**: Interface shall follow accessibility guidelines for visual impairments
* **NFR5.3**: System shall provide clear error messages and guidance
* **NFR5.4**: Help documentation shall be available in local languages

**2.6 Compatibility Requirements**

* **NFR6.1**: Mobile app shall support Android 7.0+ and iOS 12.0+
* **NFR6.2**: System shall work on devices with 2GB+ RAM
* **NFR6.3**: Model size shall be ≤50MB for mobile deployment
* **NFR6.4**: System shall function in areas with limited internet connectivity

**2.7 Environmental Requirements**

* **NFR7.1**: System shall function in temperature ranges of 5°C to 45°C
* **NFR7.2**: Application shall work under various lighting conditions
* **NFR7.3**: System shall handle images taken at different angles and distances
* **NFR7.4**: Battery usage shall be optimized for extended field use

**3. PROCESS FLOW**

**3.1 High-Level System Architecture Flow**

[Farmer] → [Mobile App] → [Local ML Model] → [Classification Result] → [Treatment Recommendations]

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[Optional Cloud Sync] → [Analytics Dashboard] → [Extension Services]

**3.2 Detailed Process Flow**

**Phase 1: Image Capture & Preprocessing**

1. **Image Acquisition**
   * Farmer opens mobile application
   * Selects camera or gallery option
   * Captures/selects maize leaf image
   * System validates image quality
2. **Image Preprocessing**
   * Resize image to model input requirements (224x224)
   * Normalize pixel values
   * Apply data augmentation if needed
   * Validate image contains maize leaf content

**Phase 2: Disease Classification**

1. **Model Inference**
   * Load pre-trained CNN model
   * Pass preprocessed image through model
   * Generate probability scores for each class
   * Apply confidence threshold filtering
2. **Result Processing**
   * Determine highest confidence prediction
   * Generate confidence score
   * Retrieve disease information from local database
   * Format results for display

**Phase 3: Result Presentation & Action**

1. **Display Results**
   * Show disease classification with confidence
   * Display disease description and symptoms
   * Present treatment recommendations
   * Provide prevention guidelines
2. **Data Storage**
   * Save diagnosis to local database
   * Store image metadata (location, timestamp)
   * Update user history
   * Prepare data for optional cloud sync

**Phase 4: Follow-up & Analytics**

1. **Cloud Synchronization** (Optional)
   * Upload anonymized data when internet available
   * Sync with central database
   * Download model updates if available
   * Backup user data
2. **Analytics & Reporting**
   * Generate individual farm reports
   * Aggregate regional disease data
   * Provide insights to extension services
   * Support policy decision-making

**3.3 Data Flow Diagram**

Input Image → Preprocessing → Feature Extraction → Classification →

Post-processing → Result Display → Data Storage → Cloud Sync → Analytics

**3.4 User Journey Flow**

1. **Farmer discovers potential disease on maize leaves**
2. **Opens mobile application**
3. **Captures clear image of affected leaf**
4. **Receives instant classification result**
5. **Reviews treatment recommendations**
6. **Implements suggested interventions**
7. **Monitors treatment effectiveness**
8. **Repeats process for ongoing monitoring**

**4. IMPLEMENTATION CONSIDERATIONS**

**4.1 Technical Stack Recommendations**

* **Mobile Development**: Flutter or React Native for cross-platform
* **ML Framework**: TensorFlow Lite or PyTorch Mobile
* **Backend**: Node.js/Python with cloud deployment
* **Database**: SQLite (local), PostgreSQL (cloud)
* **Cloud Platform**: AWS, Google Cloud, or Azure

**4.2 Model Development Pipeline**

1. Data collection and annotation
2. Model training with transfer learning
3. Model optimization and quantization
4. Mobile deployment and testing
5. Continuous improvement based on feedback

**4.3 Deployment Strategy**

* **Phase 1**: Pilot deployment in select regions
* **Phase 2**: Gradual rollout with farmer training
* **Phase 3**: National deployment with extension service integration
* **Phase 4**: Regional expansion and model refinement

**4.4 Success Metrics**

* Classification accuracy (>95%)
* User adoption rate (target: 50% of smartphone-owning farmers)
* Disease detection improvement (early detection rate)
* Yield improvement correlation
* User satisfaction scores

This comprehensive requirements document provides the foundation for developing a robust, scalable, and user-friendly maize disease detection system that can significantly impact Zimbabwe's agricultural productivity and food security.