Software Requirements Specification

Automated Potato Disease Detection Android application

Project - ICT 3206

Bachelor of Information and Communication Technology

(BICT) Degree Programme

Department of Information and Communication Technology

Faculty of Technology

Rajarata University of Sri Lanka

Mihintale

Details of the Project

Project Title : Automated Potato Disease Detection Android application

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Table of Contents

Tables of figures

1. Project Problem Statement

The disease known as potato blight, caused by the fungus Phytophthora infectants, poses a significant threat to global potato production due to its destructive and economically disastrous nature. Effective disease management relies on the prompt and accurate identification of this fungus. However, traditional identification methods are often costly, time-consuming, and may lack the necessary accuracy for effective treatment. Moreover, the rapid evolution of more aggressive pathogen strains has exacerbated the problem.

2. Project Scope

The research project aims to develop an Automated Potato Disease Detection System to address the significant threat posed by potato blight in Sri Lanka's agricultural sector. This system will leverage modern technologies such as image processing and machine learning to enable quick and accurate identification of late blight in potato crops, facilitating early detection and timely implementation of control measures to minimize crop damage.

3. Project Overview

Value of the project

- Improved disease management

  By enabling early detection of potato diseases, the system helps farmers implement timely control measures, thereby minimizing crop damage and maximizing yields.

- Enhanced food security

  By safeguarding potato crops against diseases, the system contributes to ensuring a stable food supply and mitigating the risk of food shortages.

- Economic stability

  By reducing crop losses and increasing yields, the system supports the economic livelihoods of potato farmers and contributes to the overall economic stability of Sri Lanka's agricultural sector.

- Technological advancement

  By leveraging modern technologies such as image processing and machine learning, the system represents a significant advancement in agricultural practices, positioning Sri Lanka at the forefront of innovation in crop disease management.

Project Goals

- Develop an Automated Potato Disease Detection System capable of quickly and accurately identifying late blight in potato crops using image processing technology.
- Provide a user-friendly interface for easy access and navigation, offering information on potato diseases and disorders in an easily accessible format.
- Integrate modern technologies such as remote sensing, machine learning, and mobile applications to enhance disease detection and monitoring capabilities.
- Enable early detection of disease symptoms, allowing farmers to implement timely control measures and minimize crop damage.
- Raise awareness among farmers about disease symptoms and preventive measures through knowledge transfer and educational initiatives.

The Problem it May Solve

The research project addresses several critical problems faced by potato farmers in Sri Lanka

Disease Management Challenges

Potato crops are susceptible to various diseases, including late blight, early blight, bacterial wilt, and potato virus Y, which can cause significant yield losses if not managed effectively. Traditional methods of disease identification are often time-consuming, costly, and may lack accuracy, leading to delayed intervention and increased crop damage.

Impact on Food Security

Potato farming plays a crucial role in Sri Lanka's food security and economy. However, disease outbreaks can jeopardize food production, leading to shortages and affecting the availability

and affordability of this staple crop for consumers. Ensuring the health and productivity of potato crops is essential for maintaining a stable food supply.

Economic Losses

Crop diseases not only affect food security but also have economic implications for farmers and the agricultural sector as a whole. Yield losses resulting from disease outbreaks can lead to reduced income for farmers, impacting their livelihoods and financial stability. Additionally, economic losses incurred by the agricultural sector can have ripple effects on the overall economy of the country.

Need for Technological Solutions

With the advancement of technology, there is an opportunity to leverage modern tools such as image processing and machine learning to improve disease detection and management practices. Developing automated systems capable of early disease detection can empower farmers with timely information to implement preventive measures and minimize crop losses.

Research Description

The research project involves conducting a comprehensive literature review to explore existing automated disease detection systems, agricultural image analysis techniques, and machine learning applications in agriculture. The findings from the literature review will inform the development of the Automated Potato Disease Detection System, guiding the selection of appropriate methodologies, algorithms, and technologies. Through a systematic approach encompassing problem definition, literature review, requirement analysis, system design, model development, frontend and backend development, testing, optimization, and documentation, the research project aims to deliver a robust and effective solution for potato disease detection in Sri Lanka.

4. Data Requirements

4.1.Data Sources

The system will require a comprehensive dataset of potato plant leaf images with

corresponding annotations for training and evaluation.
The data sources considered for this project include:

Academic Potato Plant Dataset: A publicly available dataset containing a diverse range of potato plant leaf images with annotated ground truth labels. This dataset can be obtained from reputable academic sources in the field of agriculture or plant pathology.

Collaborative Data Collection: Collaboration with agricultural research institutions or farms will be pursued to gain access to their de-identified plant images. The collaboration will involve obtaining necessary approvals, adhering to privacy regulations, and ensuring consent for the use of the data.

4.2. Data Collection

The data collection process will adhere to strict ethical guidelines and privacy regulations. It will involve the following steps:

Partnership with Agricultural Institutions: Establish collaborations with renowned agricultural institutions or farms to obtain access to a large and diverse collection of potato plant leaf images.

Informed Consent: Ensure proper informed consent is obtained from the institutions or farmers for the use of their de-identified potato plant leaf images in the research project. Adhere to all applicable privacy and ethical guidelines.

High-Quality Imaging: Capture high-resolution digital images of potato plant leaves using state-of-the-art imaging equipment, such as high-resolution cameras. Ensure that images capture various stages of plant growth and are of sufficient quality for accurate analysis.

4.3 Data Preprocessing

To ensure the quality and reliability of the dataset, rigorous preprocessing techniques will be applied to the collected data. The preprocessing steps will include:

Image Standardization: Normalize the images to a consistent format, such as resizing all images to a common resolution, eliminating any variations in image sizes.

Contrast and Brightness Normalization: Apply techniques to standardize image brightness and contrast, mitigating any inconsistencies caused by imaging conditions.

Artifact Removal: Employ advanced image processing algorithms to remove any noise, artifacts, or undesired elements that could affect the accuracy of the subsequent analysis.

Class Distribution Balancing: Ensure the dataset contains a balanced representation of healthy potato plant leaves and leaves infected with various diseases, mitigating bias during model training and evaluation.

4.4 Data Annotation and Labeling

The dataset will be annotated and labeled by trained experts to provide ground truth information about the presence or absence of diseases in potato plant leaves. The annotation process will adhere to the following guidelines:

Annotation Guidelines: Develop precise annotation guidelines that clearly define the criteria for identifying and labeling different diseases in potato plant leaves. Provide comprehensive documentation to ensure consistency in the annotation process.

Expert Annotation: Engage qualified experts or experienced professionals specialized in plant pathology to perform accurate and reliable annotations, ensuring high-quality ground truth labels.
Quality Assurance: Implement quality control mechanisms to verify the accuracy and consistency of the annotations, utilizing a peer-review process and resolving any discrepancies through consensus.

4.5 Data Split

To evaluate and validate the performance of the developed models, the collected dataset will be divided into distinct subsets:

Training Set: A significant portion of the dataset will be allocated for training the machine learning models. This set will be used to optimize the model's performance and learn the underlying patterns in the data.

Validation Set: A smaller portion of the dataset will be reserved for model evaluation and parameter tuning. This set will facilitate the selection of the best-performing model and help avoid overfitting.

Testing Set: A separate and independent subset of the dataset will be used to assess the final model's performance. This set will provide an unbiased evaluation of the model's ability to accurately detect diseases in potato plant leaves.

4.6 Data Privacy and Security

Respecting privacy and ensuring the security of the collected data is crucial. The following measures will be implemented to safeguard data privacy and security:

Compliance with Regulations: Strictly adhere to applicable privacy regulations, ensuring that all data handling procedures comply with legal requirements.

De-identification: Anonymize data by removing or encrypting any personally identifiable information (PII) to prevent the identification of individual plants or farms. Only authorized personnel will have access to the de-identified data.

5. Functional Requirements

5.1 Use Case Diagram

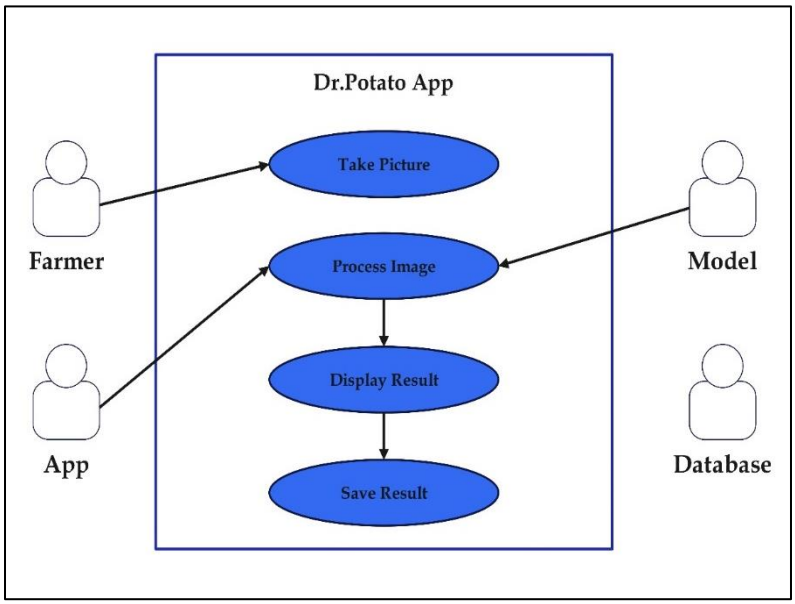

Figure 1 - Use case diagram

The following use case diagram shows the main actors and use cases for the potato disease detection application.

Actors:

Farmer: Interacts with the app.

App: Android application for disease detection.

Model: Machine learning model for disease detection.

Database: Stores results.

Use Cases:

Take Picture: Farmer uses the app to take a picture of a potato plant leaf.

Process Image: App processes the image using the machine learning model.

Display Result: App shows the result (healthy or diseased) to the farmer.

Save Result: Result is saved in the database for further analysis.

Use Case Scenarios:

Normal Scenario:

Farmer uses the app to take a picture of a potato plant leaf.

App processes the image using the machine learning model.

App displays the result (healthy or diseased) to the farmer.

Farmer can take further action based on the result, such as treating the plant if it is diseased.

Alternate Scenario:

Farmer uses the app to take a picture of a potato plant leaf.

App processes the image using the machine learning model.

App incorrectly identifies the plant as healthy or diseased.

Farmer receives inaccurate information and may need to seek additional advice or take further steps to verify the plant's health.

5.2 Activity Diagram

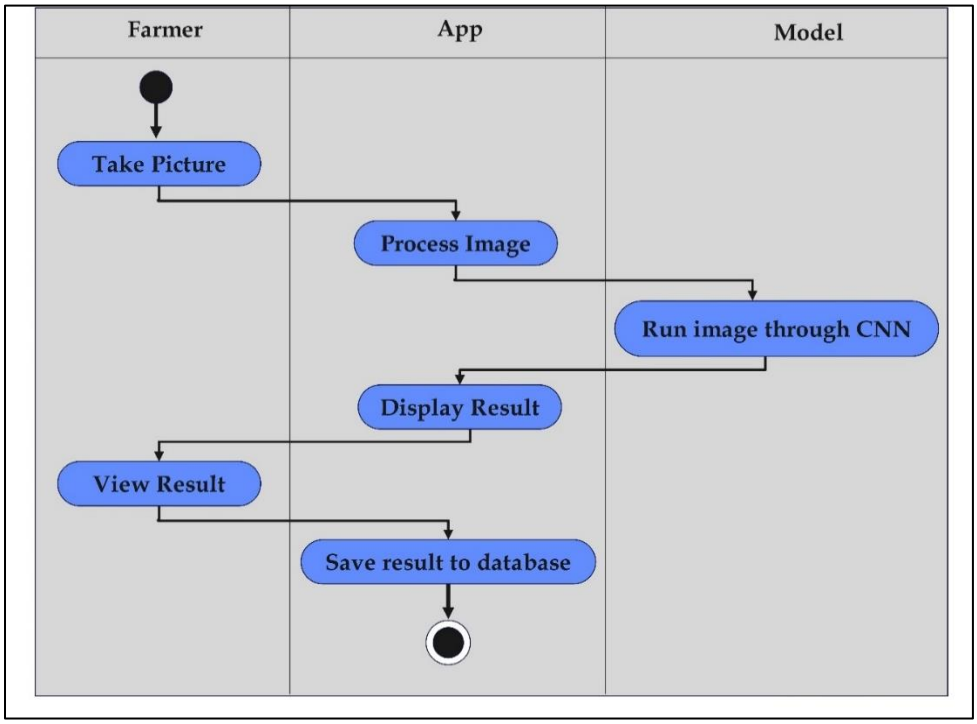

Figure 2 - Activity diagram

The following activity diagram shows the overall business process for the potato disease detection application.

The activity in the potato disease detection application involves the farmer using the app to capture an image of a potato plant leaf. The app then processes this image using a machine learning model to determine if the plant is healthy or diseased. Finally, the result is displayed to the farmer, and it can be saved in the database for future reference.

6. Non-Functional Requirements

6.1.Product requirements

- The product requirements should be aligned with user needs and expectations to deliver a solution that effectively addresses their pain points.
- Regular feedback from users should be incorporated into product requirements to ensure that the final product meets their evolving needs and preferences.

- User testing and feedback sessions should be conducted at various stages of development to validate product requirements and identify areas for improvement.

6.1.1. Usability requirement

- Intuitive User Interface: The interface should be intuitive, allowing users to easily navigate and access features without confusion.
- Multilingual Support: Consider the diverse user base and provide language options to accommodate different language preferences.

6.1.2. Efficiency requirement

- Our system prioritizes efficiency to deliver optimal performance and resource utilization.
- We have defined specific performance and space requirements to ensure smooth operation.
- Timely image processing and scalability are key aspects addressed in our efficiency requirements.
- Additionally, we emphasize minimizing storage footprint and optimizing resource usage for an enhanced user experience.

6.1.2.1. Performance requirements

- Timely Image Processing: Ensure that the application processes images quickly to provide prompt disease detection results, enhancing user satisfaction.
- Scalability: Design the application to scale effectively, accommodating increased user traffic or data volume without sacrificing performance.

6.1.2.2. space requirements

- Minimal Storage Footprint: Optimize the application's storage usage to minimize the amount of space it occupies on users' devices.
- Resource Optimization: Efficiently utilize device resources such as RAM and CPU to maintain optimal performance and responsiveness.

6.1.3. Reliability requirement

- High Accuracy: Emphasize the importance of accurate disease detection to

instill trust in the application among users.

- Resilience: Build resilience into the application to ensure consistent operation even under adverse conditions or unforeseen circumstances.

6.1.4. Portability requirement

- Device Compatibility: Ensure compatibility with a wide range of Android devices to maximize accessibility for users across different device models and manufacturers.
- Android Version Support: Support the latest Android OS versions while also maintaining backward compatibility to reach a broader user base.

6.2. Organizational Requirements

Effective project management practices are essential for ensuring successful product development, including task prioritization, resource allocation, and progress tracking. Collaboration and communication among team members are crucial for fostering a productive and cohesive work environment, facilitating efficient project execution and delivery.

6.2.1. Delivery requirement

- The application should be delivered within the specified timeline, meeting all agreed-upon milestones and deadlines.
- Regular updates and bug fixes should be provided to ensure ongoing support and maintenance.

6.2.2. Implementation requirement

- The development process should adhere to industry best practices and coding standards to ensure the reliability and maintainability of the application codebase.
- Thorough testing procedures should be followed, including unit testing, integration testing, and user acceptance testing, to identify and rectify any issues early in the development lifecycle.

6.2.3. Standard requirement

- The application should comply with relevant industry standards and guidelines for mobile application development, security, and data privacy.

6.3.External requirements

6.3.1. Interoperability requirement

- The application should be able to interact seamlessly with external systems or APIs for features such as data sharing, reporting, or integration with existing farm management software.

6.3.2. Ethical requirement

- The application should prioritize user privacy and data security, ensuring that sensitive information such as images and user data is handled confidentially and in compliance with applicable regulations

6.3.2.1. Legislative requirements

- Our system adheres to legislative standards and regulations to ensure compliance and user trust.
- We have defined specific requirements to address privacy, safety, and data protection regulations.
- Emphasis is placed on obtaining user consent, safeguarding user privacy, and maintaining data integrity.
- Additionally, safety regulations governing agricultural technology are incorporated to ensure user and device security.

6.3.2.2. Privacy requirements

- The application should obtain explicit consent from users before accessing or storing any personal data.
- It should provide options for users to control their data privacy settings, including the ability to delete stored data or opt out of data sharing.

6.3.3. Safety requirements

- The application should not compromise the safety of users or their devices, adhering to industry standards for secure mobile application development.
- It should include features to prevent unauthorized access, such as user authentication and secure data transmission protocols.

7. Software Requirements

- **Programming Language**: Python will be used for implementing the machine learning model and application logic due to its versatility and strong support for machine learning libraries.
- **App Development Framework**: React Native will be used as the app development framework, providing the tools and components necessary for building cross-platform mobile applications.
- **Deep Learning Frameworks**: TensorFlow and Keras will be utilized for building and training the deep learning models, specifically Convolutional Neural Networks (CNNs), which are effective for image classification tasks.
- **Computer Vision Libraries**: OpenCV will be used for image processing and analysis, providing tools for image enhancement, feature extraction, and segmentation.
- **Data Visualization Libraries**: Matplotlib and Seaborn will be employed for visualizing data, enabling the display of images, graphs, and charts to aid in data analysis and model evaluation.
- **Model Interpretation Libraries**: Libraries like Lime and SHAP will be utilized for interpreting the machine learning models, providing insights into how the models make predictions and which features are most influential.

Additional Software Design Considerations

- **Choice of Algorithms**: CNNs will be the primary choice for image classification tasks, as they can effectively learn features from images and are suitable for detecting patterns in potato plant leaf images.

- **Choice of Data:** The dataset should be comprehensive, containing a diverse range of potato plant leaf images with annotated ground truth labels for various diseases. The dataset should be representative of the types of diseases prevalent in potato plants.
- **Choice of Software**: Jupyter Notebook will be used for rapid prototyping and experimentation, allowing for interactive development and visualization of results. Also React Native's development tools, along with tools like Expo for rapid development and testing, will be used for building and debugging the mobile application.
- **Choice of Hardware**: The hardware requirements will depend on the size of the dataset and the complexity of the models. A machine with sufficient processing power and memory is necessary for training and evaluating the models efficiently.

8. Hardware Design

Introduction about the hardware Design for Potato Disease Detection Android App

The hardware design for the Potato Disease Detection Android App is critical for ensuring the app's functionality and usability in the field. It involves selecting and integrating components that enable image capture, machine learning model processing, and result display on a mobile device. The design aims to be efficient, portable, and cost-effective, considering the app's requirements and the practical constraints of field use.
Planned Hardware Design Components in the overall project include:

- **Camera:** A smartphone camera capable of capturing high-quality images of potato plant leaves. It should have a sufficient resolution and autofocus capability for clear image capture.
- **Mobile Device:** A smartphone or tablet with adequate processing power and memory to run the machine learning model and display the results. It should have a high-quality display for showing images and results.
- **Battery:** A reliable battery that can power the mobile device for extended periods, ensuring uninterrupted operation in the field.

- **Internet Connectivity:** Essential for accessing the Potato Disease Detection Android App and ML model stored in Google Cloud. It enables real-time updates and data synchronization.

Additional Considerations

- **Size and Weight**: The components should be compact and lightweight for ease of use in the field.
- **Durability:** The hardware should be able to withstand outdoor conditions and handling.
- **Cost:** The hardware components should be affordable, considering the overall project budget.

The specific hardware components selected will depend on the mobile device used and the project's budget constraints. However, the above components provide a basic framework for designing a hardware setup for the Potato Disease Detection Android App.

Chematic diagram of the proposed hardware design for a ML based

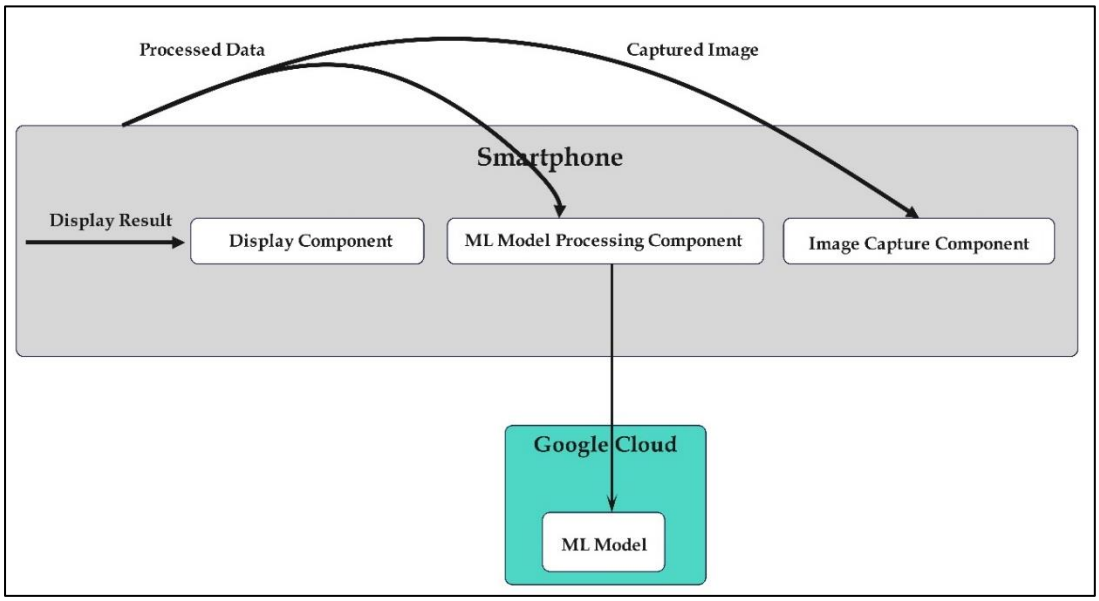

Figure 3 – chematic diagram

Explanation about the diagram

The schematic diagram represents the hardware design for a ML-based Potato Disease Detection Android App.

- **Smartphone:** The main device running the Android app. It includes three components:
- **Image Capture Component (IC):** Represents the smartphone's camera, responsible for capturing images of potato plant leaves.
- **ML Model Processing Component (MC):** Represents the part of the app that processes the captured images using machine learning (ML) algorithms to detect potato diseases.
- **Display Component (DC):** Represents the smartphone's display, where the results of the ML model's analysis are shown to the user.
- **Google Cloud:** Represents the cloud-based storage and computing resources provided by Google. It includes:
- **ML Model (MM):** The machine learning model used for disease detection. The smartphone app may interact with this model to request analysis of the captured images.

The diagram shows the flow of data and interactions between the components. The smartphone captures images using the Image Capture Component, processes them using the ML Model Processing Component, and displays the results on the Display Component. The app may interact with the Google Cloud to access the ML Model for disease detection.

Resource requirements

Hardware Components:

- **Camera Sensor:** High-resolution camera sensor for capturing detailed images of potato plant leaves.
- **Processor:** Modern processor (e.g., Snapdragon 600 series or higher) for running the Android app and processing the ML model.
- **Memory:** Sufficient RAM (e.g., 2GB or higher) for smooth app performance and ML model processing.
- **Battery:** Long-lasting battery with fast-charging capability for uninterrupted field use.
- **Display:** High-quality display (e.g., Full HD or higher resolution) for showing images and results.

- **Connectivity:** 4G or 5G support for fast internet access and Wi-Fi for local network connectivity.

Development Kits:

- **Android Development Kit:** Android Studio for app development and testing.
- **Machine Learning Framework:** TensorFlow or PyTorch for developing and integrating the ML model.
- **Image Processing Library:** OpenCV for image processing and analysis.
- **Data Visualization Library:** Matplotlib or similar for visualizing data and results.

9. Other Specific Requirements

The implementation of the Dr Potato app for detecting decreases in potatoes using image processing involves several specific requirements beyond basic functionalities. These requirements ensure the app's effectiveness, usability, and compatibility with the intended environment. Below are the details of these other specific requirements:

- **Image Quality and Resolution:**

  The app must be capable of processing images with sufficient quality and resolution to accurately detect decreases in potatoes.
  Minimum requirements for image resolution should be defined to ensure optimal performance of the image processing algorithms.

- **Real-time Processing:**

  The app should perform image processing in real-time to provide immediate feedback on potato quality.
  Response time requirements must be established to ensure timely detection of decreases in potatoes during inspection.

- **Robustness to Environmental Conditions:**

The image processing algorithms must be robust to variations in lighting conditions, background clutter, and other environmental factors commonly encountered in potato inspection environments.
The app should include mechanisms to adapt to changing environmental conditions and maintain consistent performance.

- **User Interface Design:**

A user-friendly interface is essential for ease of use by operators conducting potato inspections.
The app's user interface should be intuitive, with clear instructions and feedback provided to users during the inspection process.

- **Compatibility and Integration:**

The app should be compatible with a range of hardware devices commonly used for image capture and processing, including cameras, microcontrollers, and processors.
Integration with existing potato inspection systems or equipment should be considered to facilitate seamless adoption by users.

- **Accuracy and Precision:**

The app's algorithms must achieve high accuracy and precision in detecting decreases in potatoes to minimize false positives and negatives.
Performance metrics should be defined to evaluate the app's accuracy, including measures such as precision, recall, and F1 score.

- **Scalability:**

The app should be designed to scale efficiently to accommodate increasing demand or additional functionalities in the future.
Scalability considerations should include support for processing large volumes of images and accommodating upgrades or expansions in hardware infrastructure.

- **Data Security and Privacy:**

Measures should be implemented to ensure the security and privacy of data collected and processed by the app.
Compliance with relevant data protection regulations and standards should be considered, including provisions for data encryption, access control, and user consent.

- **Documentation and Support:**

Comprehensive documentation should be provided to guide users in the installation, configuration, and operation of the app.
Ongoing technical support and maintenance should be available to address user queries, troubleshoot issues, and provide software updates as needed.

- **Performance Monitoring and Logging:**

The app should incorporate logging functionality to record system events, errors, and performance metrics.
Monitoring tools should be implemented to track the app's resource usage, processing times, and other performance indicators for optimization and troubleshooting purposes.
These other specific requirements are essential for the successful implementation and deployment of the Dr Potato app, ensuring its functionality, usability, and reliability in potato inspection scenarios.

10. References

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