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IT4010 – Research Project - 2024

Topic Assessment Form

Project ID: 24-25J-069

1. Topic (12 words max)

Papaya Buddy - Enhancing Papaya Cultivation through Advanced Monitoring.

2. Research group the project belongs to

Software Systems & Technologies (SST)

3. Research area the project belongs to

ICT for Development (ICTD)

4. If a continuation of a previous project:

Project ID	
Year	

5. Brief description of the research problem including references (200 – 500 words max) – references not included in word count.

Papaya (Scientific name - Carica papaya) is an economically significant tropical fruit, yet its cultivation faces several critical challenges. These include disease susceptibility, pest susceptibility and the requirement for consistent fruit quality. Traditional farming methods often fall short in addressing these issues due to their reliance on manual monitoring and generalized treatment approaches [1].

One of the primary issues in papaya cultivation is the timely and accurate identification of diseases. Papaya is susceptible to a variety of diseases such as papaya mosaic virus, black spot fungus, ring spot virus, and powdery mildew, which can severely impact yield and fruit quality. These diseases manifest in different parts of the plant: the papaya mosaic virus and black spot fungus primarily affect the leaves, causing discoloration and spots, while the ring spot virus targets the fruit, leading to characteristic ring-like patterns [2], [3]. Powdery mildew, on the other hand, affects the fruit directly, compromising its marketability and consumer acceptance. The effects of these viruses are often subtle and can easily go unnoticed by the untrained human eye. Traditional disease identification methods are typically slow and prone to human error, resulting in delayed and often inadequate responses. Accurate and timely detection is crucial for effective disease management, ensuring healthy and quality crops and optimal yield [4].

Another critical challenge in papaya cultivation is the identification and management of pests, particularly mealy bugs and mites. Mealy bugs are small, sap-sucking insects that can cause significant damage by feeding on the plant's sap, leading to leaf yellowing, stunted growth, and reduced fruit quality. Mites, on the other hand, are tiny arachnids that also feed on the plant's sap, causing similar issues such as leaf discoloration, curling, and defoliation. The damage caused by these pests can severely impact the health and productivity of papaya plants. However, identifying these pests can be challenging due to their small size and the subtlety of early infestation signs, which are often missed by the untrained eye. Traditional pest identification methods are labor-intensive and often ineffective, leading to delayed responses and increased crop damage. Timely and accurate pest identification is essential for implementing effective control measures and ensuring healthy papaya cultivation [5].

The other problem of papaya cultivation is compounded by numerous diseases and nutritional deficiencies beyond those commonly identified through image capture. While diseases like mosaic, boron deficiency, black spot, mites, mealy bugs, ring spot, and Phytophthora are well-documented, many others exist that are challenging to identify solely through visual means [6]. Some parts of the plant, crucial for disease diagnosis, may be inaccessible for photography. This limitation hinders accurate and timely detection, leading to ineffective disease management and potential yield loss [7]. Addressing these gaps is critical for enhancing the resilience and productivity of papaya crops, requiring innovative approaches that complement visual inspection with advanced diagnostic methods.

Our project aims to develop a comprehensive Smart Monitoring System for Papaya Cultivation, known as Papaya Buddy, which integrates advanced text processing techniques, machine learning models, interactive chatbot technology, and personalized remedy suggestion systems. This system will provide timely and accurate identification of diseases, pests, and nutritional deficiencies, thereby improving disease management, enhancing crop yield, and ensuring consistent fruit quality [8], [9].

References

[1]. Department of Agriculture, "Papaya Cultivation," https://doa.gov.lk/fruit-crops-papaw-e/. Accessed: July 14, 2024.

[2]. V. Kumar, D. Banerjee, D. Upadhyay, M. Singh and K. R. Chythanya, "Hybrid Model for Effective Papaya Leaf Disease Diagnosis," 2024 International Conference on E-mobility, Power Control and Smart Systems (ICEMPS), Thiruvananthapuram, India, 2024, pp. 01-05.

[3]. CABI, "Papaya," https://www.cabi.org/?q=papaya&order=relevance-asc. Accessed: July 14, 2024.

[4]. Department of Agriculture, "Fruit Research and Development Institute," https://doa.gov.lk/frdi-home-english/. Accessed: July 14, 2024.

[5]. Department of Agriculture, "Plant Virus Indexing Centre - Homagama," https://doa.gov.lk/pvic-homagama/. Accessed: July 14, 2024.

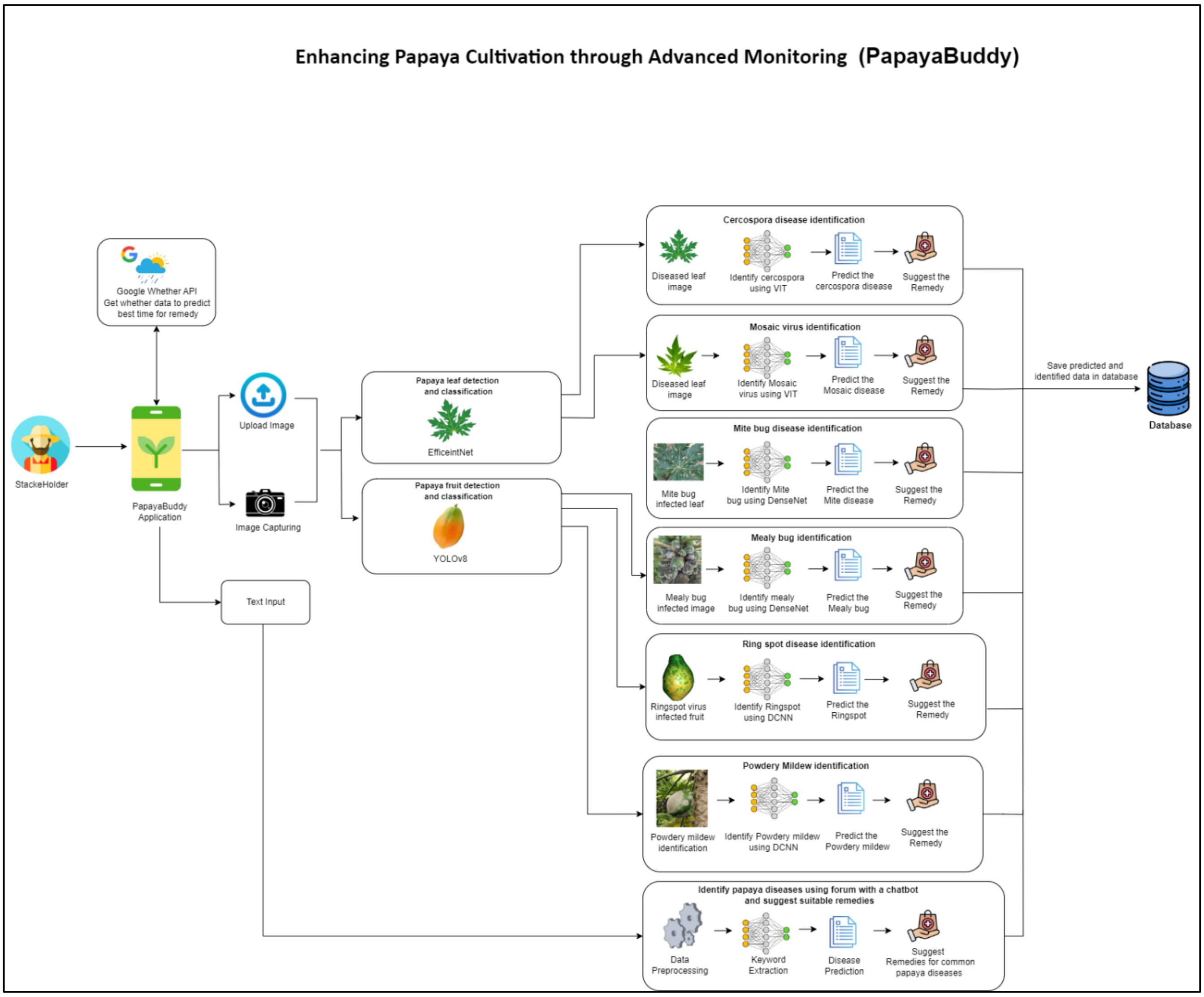
[6]. Hadabima Authority of Sri Lanka, "Hadabima Authority," http://www.hadabima.gov.lk/index.php/en/. Accessed: July 14, 2024.

[7]. Abeysinghe, Saman & Widanagamage, Shirani & Arachchi, I.M.M. & Dickinson, M.. (2016). Occurrence of phytoplasma diseases of papaya in Sri Lanka. Acta Horticulturae. 25-30.

[8]. K. H. Sarananda, S. T. Balasuriya, K. Ganeshalingam, "Quality of papaya variety 'Rathna' as affected by postharvest handling: A review," Asian Journal of Bio Science, vol. 8, no. 2, pp. 470-474, 2013. [Online]. Available: http://researchjournal.co.in/upload/assignments/8_470-474.pdf. [Accessed: July 14, 2024].

[9]. Das, Sukhen Chandra (2013). "Studies on papaya cultivation and evaluation of different varieties and hybrids in Tripura." Asian J. Hort., 8(2) : 470-474.

6. Brief description of the nature of the solution including a conceptual diagram (250 words max)



7. Brief description of specialized domain expertise, knowledge, and data requirements (300 words max)

The development of a Smart Monitoring System (Papaya Buddy) requires specialized expertise and knowledge in several key areas, including plant pathology, agronomy, image processing, machine learning, and data management.

Data Collection and Management

High-quality, comprehensive datasets are crucial for training and validating machine learning models. This includes collecting images and data from both affected and healthy papaya plants, documenting symptoms at various disease stages, and gathering data on environmental conditions. Continuous real-time data from imaging devices are necessary to maintain an up-to-date monitoring system. Data management expertise is essential for organizing and preprocessing these datasets to ensure they are suitable for model training and validation.

Our data collection spans diverse sources crucial for our research, including the Fruit Research and Development Institute in Horana, the Plant Virus Indexing Centre in Homagama, the Hadabima Authority of Sri Lanka, the Gowijana Sewa Center in Gampaha, and two papaya farms in Diwlapitiya. These sources provide us with valuable empirical data and practical insights essential for validating our models and developing innovative solutions for the challenges in papaya cultivation. Our gathered data set are here.

Plant Pathology and Agronomy

Experts in plant pathology are essential for accurately identifying and understanding the symptoms of various papaya diseases, including mosaic, cercospora, boron deficiency, black spot, mites, mealy bugs, ring spot, powdery mildew and Phytophthora. Agronomists provide critical insights into the growth requirements and optimal conditions for different papaya varieties, which are necessary for developing precise disease identification and management strategies.

Machine Learning

Data scientists and machine learning experts play a pivotal role in developing and training models for plant disease and pest disease identification, disease progression tracking, and fruit ripeness categorization. Convolutional Neural Networks (CNNs) are commonly used for image classification tasks due to their ability to automatically extract relevant features from images. These experts also develop and validate models that can accurately classify diseases and ripeness stages, ensuring the models are robust and reliable across different datasets and field conditions.

Image Processing

Image processing specialists are crucial for developing techniques to analyze visual symptoms of diseases. This involves preprocessing images to enhance quality, segmenting images to isolate affected areas, and extracting features that distinguish between healthy and diseased plants. Expertise in image processing is vital for creating robust systems that can handle variations in image quality and environmental conditions.

Field Testing

Field testing specialists are needed to validate the performance of the developed models in real-world conditions. This involves deploying the system in various field settings, collecting additional data, and refining the models based on field performance. Their expertise ensures that the system is practical and effective for use by farmers.

Software Engineering Aspects

Developing the Smart Monitoring System for Papaya Cultivation (Papaya Buddy) involves key software engineering aspects for robustness and user-friendliness. The architecture uses a microservices approach for modularity and scalability, with Firebase providing real-time updates and visual alerts. Flutter ensures a cross-platform, intuitive user interface. The backend, built with Node.js and Express, handles API requests and database interactions, while Python manages advanced text processing and machine learning. CI/CD pipelines with Jenkins and GitHub Actions automate updates, and code quality is ensured with ESLint and Prettier. NLTK, TextBlob, and Gensim are used for text processing, and scikit-learn for disease classification. Additionally, AWS supports cloud storage and computing, Twilio sends SMS notifications, D3.js provides data visualization, and Docker and Kubernetes manage containerization and orchestration.

In summary, developing Papaya Buddy for papaya cultivation requires a multidisciplinary approach, combining expertise in plant pathology, agronomy, image processing, machine learning, data management and software engineering aspects. Comprehensive data collection and rigorous field testing are essential for creating an effective and reliable system.

8. Objectives and Novelty

Main Objective The main objective of our system is to develop and implement an integrated smart monitoring system that enhances the efficiency, productivity of papaya cultivation through real-time data acquisition, analysis, and automated decision support.			
Member Name	Sub Objective	Tasks	Novelty
Peiris M.M.A. E	Papaya mosaic virus and Cercospora disease identification using papaya leaves and suggest the remedies.	• **Identify if Papaya leaf:** Collect a diverse dataset of papaya leaves images, including both healthy and diseased leaves. • **Mosaic Virus and Cercospora disease Detection:** Use EfficientNet for binary identification of whether an image contains a papaya leaf and Train a Vision Transformer model for transfer learning on a broad agricultural dataset and fine-tune with	By integrating for precise binary identification of papaya leaf and Vision Transformers (ViTs) for detailed disease detection, our hybrid model represents a departure from traditional CNN methods. EfficientNet excels in accurately distinguishing images containing papaya leaves, leveraging its efficiency and robustness in binary classification tasks. ViTs enhance disease identification by utilizing

		annotated leaf specific images for accurately identification mosaic disease and Cercospora disease. • **Remedy Suggestion System**: Integrate a comprehensive database of remedies for mosaic virus and Cercospora disease, including both preventive measures and treatments. Upon detecting an infected papaya fruit, the system will provide actionable suggestions for managing and mitigating the disease. The remedy suggestions will be tailored based on the severity and progression of the infection, offering users practical and effective solutions. This component will be built using a robust backend system and integrated	global attention mechanisms to preserve intricate details critical for detecting subtle signs of papaya leaf diseases. This innovative approach providing a precise tool for detecting and diagnosing diseases effectively.

		with the machine learning models for seamless operation.	
Perakum K.K. P	Papaya Ringspot virus and Powdery Mildew identification using papaya fruits and suggest the remedy.	• **Identify if Papaya fruit:** Use YOLOv8 to identify whether an image contains a papaya fruit and determine its health or not. Collect a diverse dataset of images annotated with bounding boxes and labels indicating whether the fruit is healthy or unhealthy. Train the YOLOv8 model on this dataset. YOLOv8's capability to quickly and accurately detect and classify objects ensures precise identification of papaya fruits and their health status for agricultural monitoring. • **Ringspot Virus and Powdery Mildew Detection**: Utilize a Deep Convolutional Neural	The novelty of this component lies in its integrated approach to managing Papaya Ringspot Virus and Powdery Mildew using advanced deep learning techniques. Utilizing YOLOv8 ensures precise identification of papaya fruits and their health status, distinguishing between healthy and unhealthy fruits efficiently. For detailed disease classification, a Deep Convolutional Neural Network (DCNN) is employed to differentiate between Ringspot Virus and Powdery Mildew in unhealthy fruits. Additionally, the system includes a comprehensive remedy suggestion

		Network (DCNN) to differentiate between Ringspot Virus and Powdery Mildew in unhealthy papaya fruits. First, extract features from the papaya fruit images identified and localized by the trained YOLOv8 model. Then, train the DCNN on these extracted features to accurately classify the unhealthy fruits as either Ringspot-infected or Powdery Mildew-infected, enhancing disease detection and management in papaya cultivation. • **Remedy Suggestion System**: Integrate a comprehensive database of remedies for Ringspot Virus, including both preventive measures and treatments. Upon detecting an infected papaya fruit, the system	component, enhancing disease management with tailored interventions that improve agricultural productivity. This streamlined framework not only effectively detects and diagnoses diseases but also simplifies the implementation of targeted solutions, marking a significant advancement in papaya cultivation practices.

		will provide actionable suggestions for managing and mitigating the disease. The remedy suggestions will be tailored based on the severity and progression of the infection, offering users practical and effective solutions. This component will be built using a robust backend system and integrated with the machine learning models for seamless operation.	
Mangchanayaka M.V. V	Mite disease and Mely bug disease identification and suggest the remedy.	• **Identify Mite disease and Mealy Bug:** Accurately identify and diagnose mite disease and mealy bug infestations in papaya plants using advanced image processing techniques. The component leverages DenseNet, a type of Convolutional Neural	As a novel approach, DenseNet uses to establishes direct connections between layers with the same feature-map size, ensuring maximum information flow throughout the network. DenseNet introduces dense connectivity, where each layer is connected to every

		Network (CNN), to ensure maximum information flow between network layers, enhancing its capability to distinguish between complex disease patterns. • **Visual Alerts**: Identified diseased areas on plant images are highlighted with bounding boxes or heat maps. Different colors indicate the type and severity of the disease, providing clear visual cues to the user. • **Remedy Suggestion System**: Integrate a comprehensive database of remedies for Mite disease and Mely bug disease, including both preventive measures and treatments. Upon detecting an infected papaya fruit, the system will provide actionable suggestions	other layer in a feed-forward fashion. This architecture allows for the reuse of features from earlier layers, leading to more efficient information flow and utilization. DenseNet allows for the efficient distinction of small and intricate pest infestations, such as mites and mealy bugs.

		for managing and mitigating the disease. The remedy suggestions will be tailored based on the severity and progression of the infection, offering users practical and effective solutions. This component will be built using a robust backend system and integrated with the machine learning models for seamless operation.	
Senevirathne U.W.H. N	Incorporates an NLP-based questionnaire to address diseases not identifiable through images, allowing detailed symptom descriptions and providing disease names and preventive measures.	• **Define and Collect Data:** Gather text descriptions from experts detailing symptoms and corresponding diseases/nutritional deficiencies and create a labeled dataset where each description is associated with the respective disease or nutritional deficiency.	This novelty of this component lies advanced text processing (using NLTK and Gensim), specific agricultural machine learning models (such as Naive Bayes), interactive Natural Language based questionare, and personalized remedy suggestion systems tailored for papaya

		• **Preprocess the Data:** Use NLTK for text preprocessing to tokenize the text into words, reduce them to their root forms (lemmatization), and remove stop words to focus on meaningful content. • **Feature Extraction:** Employ sklearn to convert preprocessed text data into numerical features using TF-IDF (Term Frequency-Inverse Document Frequency). This quantifies the importance of words in the dataset and utilize Gensim for creating word embeddings to understand the context and semantic relationships among symptoms and diseases.	cultivation.

		• **Train Machine Learning Model:** Choose Naive Bayes from sklearn model and train this model on the labeled dataset to classify symptoms into corresponding diseases or nutritional deficiencies. • **Integrate Natural Language Processing based Questioning:** Use Rasa framework to develop a natural language processing based predefined questions for the chatbot to ask users about symptoms and based on user responses, generate follow-up questions dynamically to gather more specific information and accurately identify the issue using decision tree.	

		• **Remedy Suggestion:** Develop a separate AI model or utilize rules-based systems to suggest remedies based on identified diseases or deficiencies. Use supervised learning with labeled treatment data or expert knowledge to train this model.	

9. Supervisor checklist

a) Does the chosen research topic possess a comprehensive scope suitable for a final-year project?

Yes	✓	No	

b) Does the proposed topic exhibit novelty?

Yes	✓	No	

c) Do you believe they have the capability to successfully execute the proposed project?

Yes	✓	No	

d) Do the proposed sub-objectives reflect the students' areas of specialization?

Yes	✓	No	

e) Supervisor's Evaluation and Recommendation for the Research topic:

Approved.

10. Supervisor details

	Title	First Name	Last Name	Signature
Supervisor	Ms	Hansi	De Silva	(for) [signature]
Co-Supervisor	Ms	Thilini	Jayalath	[signature]
External Supervisor	Mrs	RA Thilini	Anuradha	[signature]

Summary of external supervisor's (if any) experience and expertise
Working at fruit Research & Development Institute, Horana in Agronomy Devision as research assistance.

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Topic Assessment Form

This part is to be filled by the Topic Screening Panel members.

Acceptable: Mark/Select as necessary

Topic Assessment Accepted	
Topic Assessment Accepted with minor changes (should be followed up by the supervisor)*	✓
Topic Assessment to be Resubmitted with major changes*	
Topic Assessment Rejected. Topic must be changed	

* Detailed comments given below

Comments

- Extensibility (Auto ML).
- Transfer learning.
- if using LLMs (RAG), need to have additional contribution
- Compare models (CNN, ViT) on accuracy / performance.

The Review Panel Details

Member's Name	**Signature**
Dhashen Kumara	[signature]
Thilini Jayalath	[signature]
Rivoni De Zoysa.	[signature]

*__Important__:

1. According to the comments given by the panel, make the necessary modifications and get the approval by the **Supervisor** or the **Same Panel**.
2. If the project topic is rejected, identify a new topic, and follow the same procedure until the topic is approved by the assessment panel.