Team ID - 592104

Project Name - Safeguarding Agriculture: AI-Enabled Prognostication of Farm Insect Threats

1. Introduction

1.1 Project Overview :

"Safeguarding Agriculture: AI-Enabled Prognostication of Farm Insect Threats" stands as a groundbreaking initiative that harnesses the potential of cutting-edge technologies to fortify agriculture against the perils of insect infestations. The core mission is to equip farmers with an intelligent system that foresees and combats potential threats from harmful insects, safeguarding their crops and livelihoods.

1.2 Purpose :

At its essence, the project focuses on early detection and identification, deploying advanced AI algorithms to swiftly pinpoint and categorise various insect species. By providing farmers with detailed profiles, including high-resolution images and taxonomy information, the system facilitates a deeper understanding of insect life cycles, behaviours, and preferred habitats.
In line with its data-driven approach, the project analyses historical data to offer personalised preventive measures. This not only empowers farmers with actionable insights but also establishes a collaborative farming community. The platform encourages knowledge sharing, allowing farmers to exchange best practices and collectively address insect threats.
It envisions a resilient and informed farming community, poised to overcome the challenges posed by farm insect threats. Through a harmonious blend of advanced technologies and collaborative tools, the project strives to redefine the landscape of agricultural resilience and fortify the backbone of our food supply in a way that is accessible, practical, and community-driven.

2. Literature survey

2.1 Existing Problem :

- Limited Timely Detection: Conventional methods often struggle to detect insect threats in their early stages, leading to delayed responses and increased crop damage.
- Resource Intensiveness: Traditional insect monitoring requires significant human resources, making it challenging to scale for large agricultural areas.
- Ineffective Preventive Measures: The lack of precise information about insect behaviour hampers the development of targeted and effective preventive measures.

2.2 References :

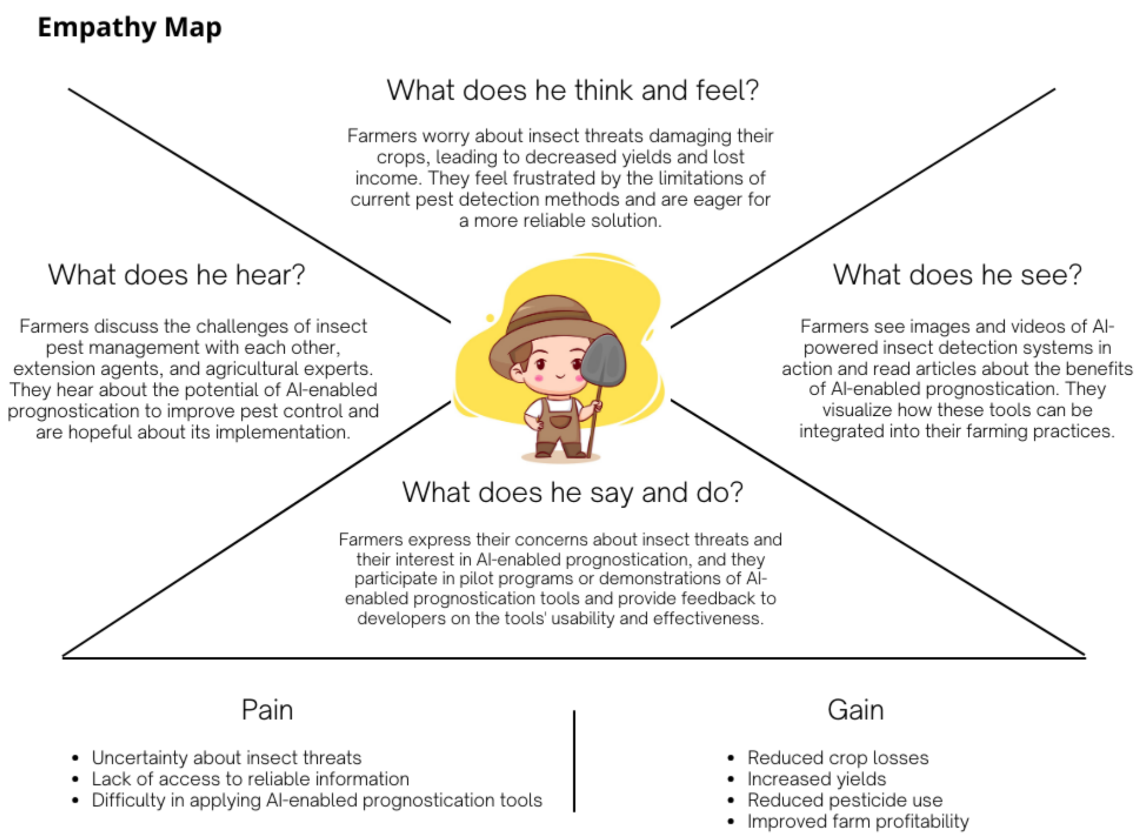
- https://www.e3s-conferences.org/articles/e3sconf/pdf/2023/24/e3sconf_icseret2023_05003.pdf
- D.I. Guest, in Encyclopaedia of Applied Plant Sciences (Second Edition),(2017)- https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/plant-pests

2.3 Problem Statement Definition :

Insect pests pose a major threat to global agriculture, causing substantial crop losses and economic damage. Traditional methods of insect pest detection and control are often ineffective due to the difficulty in predicting outbreaks and targeting pest management strategies. AI-enabled prognostication offers a promising solution to these challenges by providing farmers with early warning of potential insect threats and generating tailored pest management recommendations. The successful implementation of AI-enabled prognostication is expected to significantly reduce crop losses, pesticide use, and improve farm profitability while enhancing food safety and empowering farmers.

3. Ideation & Proposed Solution

3.1 Empathy Map Canvas:



3.2 Ideation & Brainstorming:

Step-1: Team Gathering, Collaboration and Select the Problem Statement

First we made our team consisting of Subhradip Bodhak, Aakash Bhowmick, Saptarshi Mukherjee and Supratik Pal.

Then, we decided we will be taking on the Problem Statement - "Safeguarding Agriculture: AI-Enabled Prognostication of Farm Insect Threats".

Now we will move on and take a look at the different ideas provided by our team members.

Step-2: Brainstorm, Idea Listing and Grouping

Ideas:

Member 1 Saptarshi:

- A collaborative platform should be there that facilitates knowledge sharing among farmers, enhancing the AI system's predictive capabilities through collective intelligence.
- We should use machine learning algorithms to suggest optimal crop rotation strategies based on insect life cycles, disrupting pest populations.

Member 2 Aakash:

- We should develop an AI model using Ultralytics YOLOv8 for real-time detection of farm insect threats and explore different insect species and their distinctive features for accurate identification.
- Combine the insect threat model with weather data to predict and assess the likelihood of insect infestations based on environmental conditions.
- Identify key weather variables that influence insect activity.

Member 3 Subhradip:

- Create a user interface using HTML, CSS, and JS to display real-time insect threat information and ensure the interface is intuitive for farmers and provides actionable insights.
- Develop a feature to analyze historical data and trends in insect threats to improve the accuracy of predictions.
- Use Flask to create a backend for storing and retrieving historical data.

Member 4 Supratik:

- Utilise Fetch API/AJAX for seamless communication between the backend and frontend.
- We should implement localised pest forecasting tailored to specific geographical areas to help farmers anticipate and prepare for upcoming insect threats.

Step-3: Idea Prioritisation

- **Priority 1 :** Create a user interface using HTML, CSS, and JS to display real-time insect threat information and ensure the interface is intuitive for farmers and provides actionable insights.
- **Priority 2 :** Use Flask to create a backend for storing and retrieving historical data.
- **Priority 3 :** We should use machine learning algorithms to suggest optimal crop rotation strategies based on insect life cycles, disrupting pest populations.
- **Priority 4 :** We should develop an AI model using Ultralytics YOLOv8 for real-time detection of farm insect threats and explore different insect species and their distinctive features for accurate identification.
- **Priority 5 :** Utilise Fetch API/AJAX for seamless communication between the backend and frontend.

4. Requirement Analysis

4.1 Functional requirement

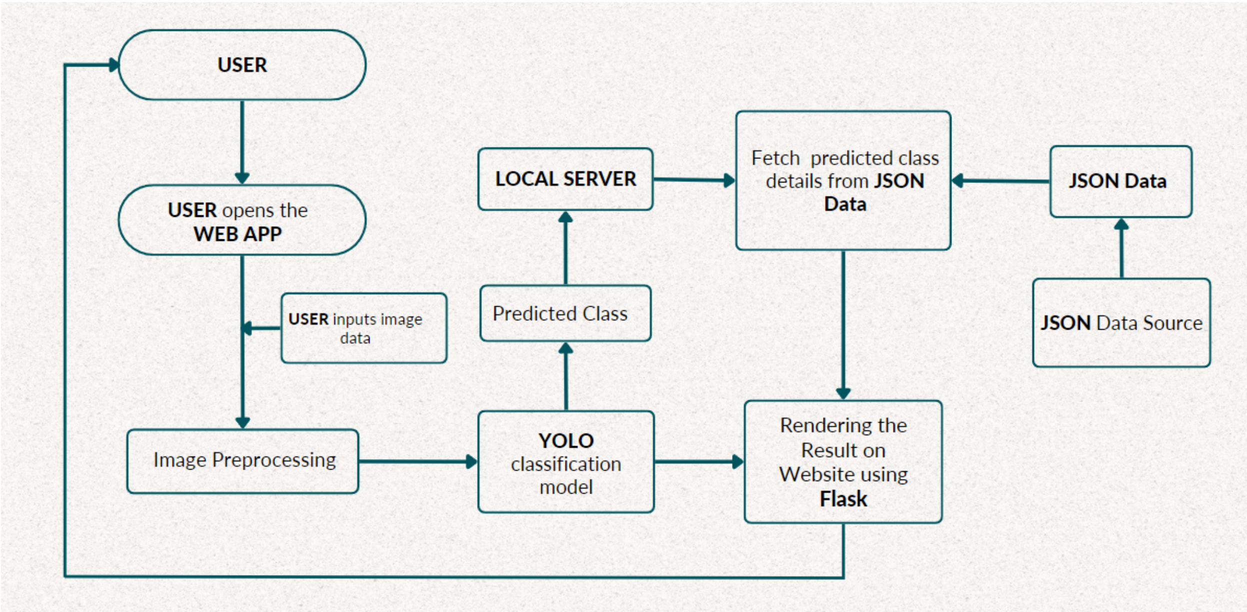
- User should upload a picture of the insect they want to know about
- User will get to know about the insect being predicted from the image
- User will know which insecticide is effective to eradicate the insect
- User will get to know some popular brands selling the specific insecticides

4.2 Non Functional requirement

S. No.	Parameter	Values	Screenshot
1.	Model Summary	**-YOLOv8n-cls summary (fused): 73 layers, 1454095 parameters, 0 gradients, 3.3 GFLOPs**	Ultralytics YOLOv8.0.215 🚀 Python-3.9.6 torch-2.1.1+cpu CPU (AMD Ryzen 5 4600H with Radeon Graphics) YOLOv8n-cls summary (fused): 73 layers, 1454095 parameters, 0 gradients, 3.3 GFLOPs
2.	Accuracy	Training Accuracy - 0.958 Validation Accuracy -0.806	est: D:\VIT_Morning_Slot-main\farm_insects_ds\farm_insects_splitted\test... found 72 images in 15 classes classes top1_acc top5_acc: 100%| | 3/3 [00:02<00:00, 1.48it/s] all 0.806 0.958
3	Confidence Score (Only Yolo Projects)	Class Detected - 15 Confidence Score - 0.79	0.93149 0.83131 0.80742 0.79326

5. Project Design

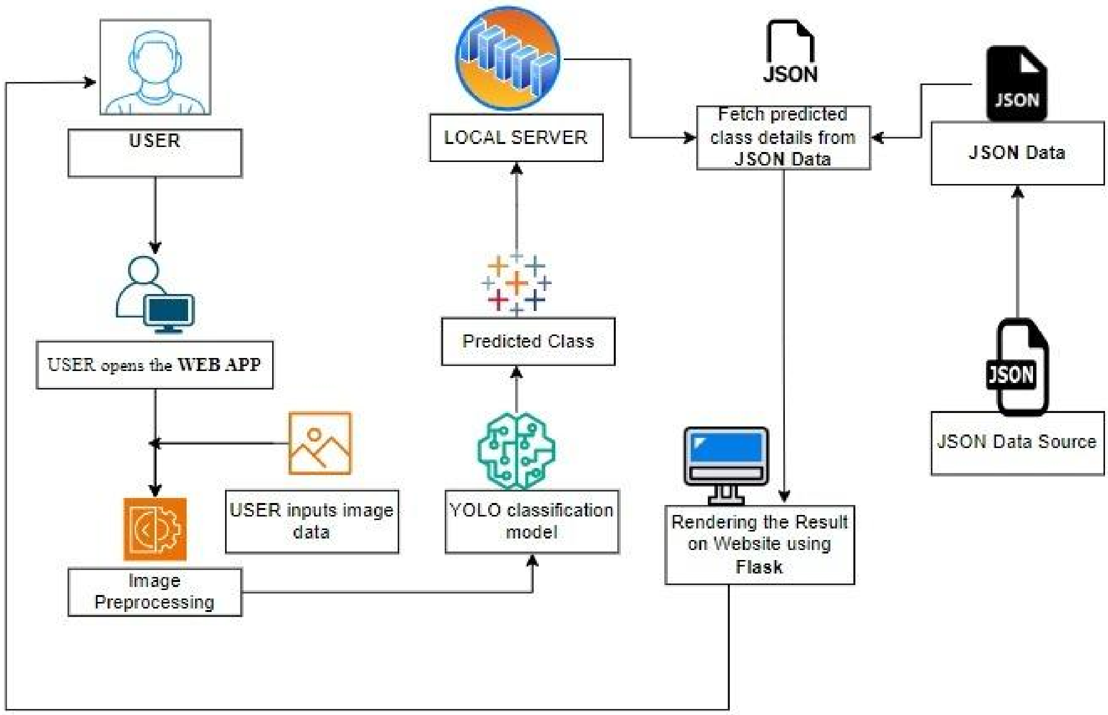
5.1 Data Flow Diagrams & User Stories:



Sprint	**Functional Requirement (Epic)**	**User Story Number**	**User Story / Task**	**Story Points**	**Priority**
Sprint-3	Home	USN-1	As a user, I can open the application and access its services through a web app.	2	High
Sprint-3		USN-2	As a user, I will have a simple user interface that will allow me to understand and enjoy the services with ease.	1	High
Sprint-1	Predict	USN-3	As a user, I will be able upload an image of an insect and it will help me identify it.	2	Low
Sprint-1		USN-4	As a user, I will be able to get more details about the	2	Medium

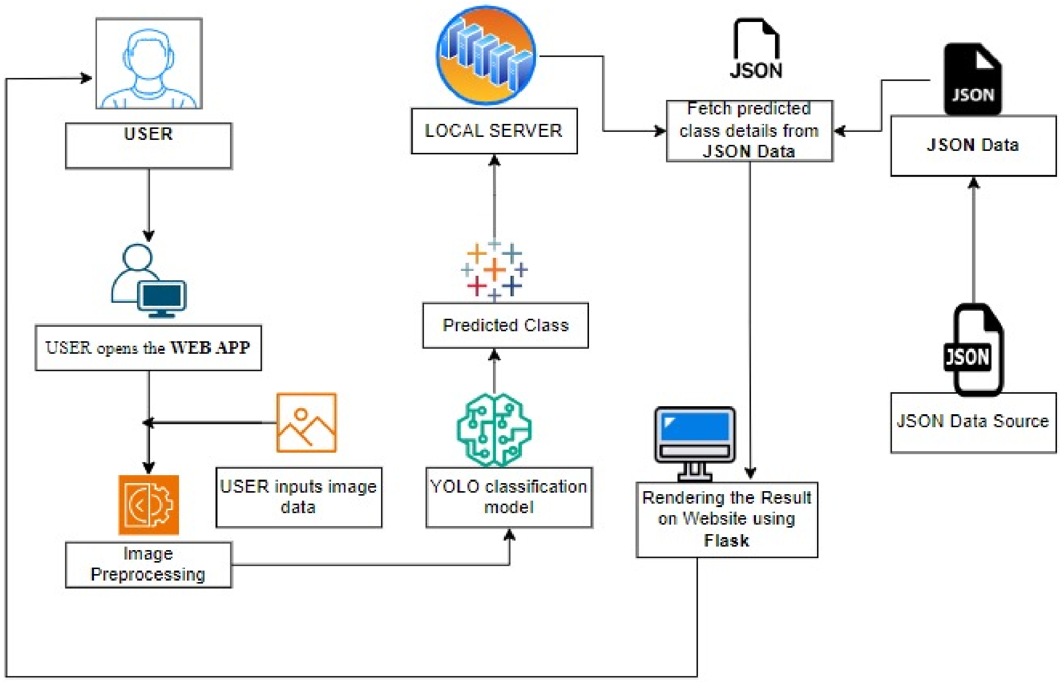
			uploaded insect’s image.		
Sprint-2		USN-5	As a user, I will be able to know about some insecticides that will be effective against the predicted insect.	1	High

5.2 Solution Architecture:



6. Project Planning & Scheduling

6.1 Technical Architecture



6.2 Sprint Planning & Estimation

Sprint	Functional Requirement (Epic)	User Story Number	User Story / Task	Story Points	Priority	Team Members
Sprint-3	Home	USN-1	As a user, I can open the application and access its services through a web app.	2	High	Aakash Bhowmick
Sprint-3		USN-2	As a user, I will have a simple user interface that will allow me to understand and enjoy the services with ease.	1	Medium	Saptarshi Mukherjee
Sprint-1	Predict	USN-3	As a user, I will be able upload an image of an insect and it will help me identify it.	2	High	Supratik Pal
Sprint-1		USN-4	As a user, I will be able to get more details about the uploaded insect's image.	2	Medium	Supratik Pal and Subhradip Bodhak

Sprint-2		USN-5	As a user, I will be able to know about some insecticides that will be effective against the predicted insect.	1	High	Subhradip Bodhak

6.3 Sprint Delivery Schedule

Sprint	**Total Story Points**	**Duration**	**Sprint Start Date**	**Sprint End Date (Planned)**	**Story Points Completed (as on Planned End Date)**	**Sprint Release Date (Actual)**
Sprint-1	20	6 Days	03 Nov 2023	08 Nov 2023	20	29 Nov 2023
Sprint-2	20	6 Days	09 Nov 2023	14 Nov 2023	20	15 Nov 2023
Sprint-3	20	6 Days	15 Nov 2023	20 Nov 2023	20	21 Nov 2023

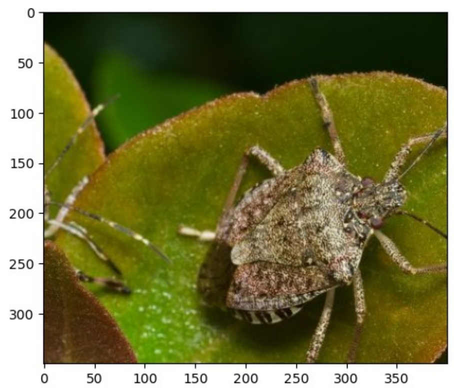
7.Coding and Solutioning

7.1 Feature 1:

Predictions

In [3]:
```
image_path="d:/VIT_Morning_Slot-main/farm_insects_ds/farm_insects_splitted/Test/Brown Marmorated Stink Bugs/Image_93.jpg"
results=model(image_path)
prob_list = results[0].probs.data.tolist()
names_dict=results[0].names
testImage = img.imread(image_path)
plt.imshow(testImage)
plt.show()
print(names_dict[prob_list.index(max(prob_list))])
```

```
image 1/1 d:\VIT_Morning_Slot-main\farm_insects_ds\farm_insects_splitted\Test\Brown Marmorated Stink Bugs\Image_93.jpg: 224x224
Brown Marmorated Stink Bugs 0.99, Spider Mites 0.01, Aphids 0.00, Thrips 0.00, Fall Armyworms 0.00, 60.0ms
Speed: 10.0ms preprocess, 60.0ms inference, 0.0ms postprocess per image at shape (1, 3, 224, 224)
```



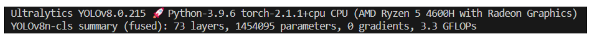
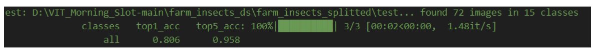

```
Brown Marmorated Stink Bugs
```

We are storing the path of the image in the “*image_path*” variable. Then we are passing the image to the pre-trained YOLOv8 model to make predictions which is getting stored in “*result*” variable.Then the name of the predicted insect is fetched from the “*result*” variable using “*names_dict = results[0].names*” which is getting stored in ‘*names_dict*” variable. Then, we are storing the input image in the “*testImage*” variable. At last we are outputting the image along with the predicted name of the insect.

7.2 Feature 2 :

The model predicts the insect and gives additional information that would be helpful to the user to effectively tackle their issues.

8. Performance Testing

S. No.	Parameter	Values	Screenshot
1.	Model Summary	**-YOLOv8n-cls summary (fused): 73 layers, 1454095 parameters, 0 gradients, 3.3 GFLOPs**	
2.	Accuracy	Training Accuracy - 0.958 Validation Accuracy -0.806	

3	Confidence Score (Only Yolo Projects)	Class Detected - 15 Confidence Score - 0.79	0.93149 0.83131 0.80742 0.79326

9. Results

10. Advantages and Disadvantages

10.1 Advantages:

- Reduced crop losses: AI-enabled prognostication can help farmers to reduce crop losses by providing them with early warning of potential insect outbreaks. This allows farmers to take preventive measures, such as applying pesticides or using other pest control methods, before the insects have caused damage to the crop.

- Increased yields: By reducing crop losses, AI-enabled prognostication can help farmers to increase their yields. This can lead to increased profits and improved food security.

- Reduced pesticide use: AI-enabled prognostication can help farmers to reduce their use of pesticides by targeting their applications more effectively. This can help to protect human health and the environment.

- Improved farm profitability: By reducing crop losses, increasing yields, and reducing pesticide use, AI-enabled prognostication can help to improve farm profitability. This can make farms more sustainable and resilient in the face of challenges such as climate change and pests and diseases.

- Improved pest management decision-making: AI-enabled prognostication can provide farmers with more accurate and timely information about insect threats, which can help them to make better decisions about pest management.

10.2 Disadvantages:

- Data dependency: AI-enabled prognostication is highly dependent on the quality and quantity of data available. If the data is inaccurate, incomplete, or biased, the predictions made by AI models will be unreliable.

- Model development and maintenance: Developing and maintaining AI models can be expensive and time-consuming. This can make it difficult for small farmers to access and use AI-enabled prognostication.

- Farmer adoption: Farmers may be reluctant to adopt AI-enabled prognostication due to concerns about the cost, complexity, and reliability of the technology.

- Potential for misuse: AI-enabled prognostication could be misused by farmers to apply pesticides excessively, which could harm human health and the environment.

11.Conclusion

Our project has successfully leveraged cutting-edge technologies to address the critical issue of safeguarding agriculture from insect threats. By implementing Ultralytics YOLOv8, a state-of-the-art object detection model, we have achieved accurate and efficient identification of farm insect threats. The use of AI has significantly improved the speed and precision of our prognostication system.

The integration of Python, HTML, CSS, JS, Flask, and Fetch API/AJAX has allowed us to create a user-friendly web-based interface for farmers and agricultural stakeholders. The Flask framework facilitated seamless communication between the frontend and backend, ensuring a smooth user experience. The interactive features powered by JavaScript, along with a well-designed HTML and CSS layout, enhance the accessibility and usability of our application.

The Fetch API/AJAX implementation further improves the real-time capabilities of our system, enabling dynamic updates and data retrieval without the need for page reloads. This responsiveness is crucial in the agricultural context, where timely information can make a significant impact on decision-making.

As we move forward, there is potential for expanding the capabilities of our system by incorporating additional data sources, improving the model's training with more diverse datasets, and enhancing the user interface based on feedback from the farming community. The open-source nature of the technologies used in this project encourages collaboration and future development by the wider community.

In summary, our AI-enabled prognostication system, powered by Ultralytics YOLOv8 and a robust web-based interface, represents a significant step towards sustainable and technology-driven agriculture. By empowering farmers with timely and accurate information, we contribute to the overall goal of safeguarding agriculture and ensuring food security in the face of evolving challenges.

12.Future Scope

- Implementing and fine-tuning a variety of AI models to address specific insect threats. This could involve experimenting with different architectures, such as convolutional neural networks (CNNs), recurrent neural networks (RNNs), or even advanced transformer models for more intricate insect threat predictions.

- Developing user-friendly mobile applications that leverage the power of AI to provide farmers with instant and actionable insights. These applications could serve as a comprehensive tool for monitoring, decision-making, and communication related to insect threats.

- Establishing a framework for global collaboration and data sharing among agricultural communities, research institutions, and technology providers. This collaborative approach can lead to a more comprehensive understanding of insect threats on a global scale and the development of solutions that transcend geographical boundaries.

- Implementing a feedback loop for continuous model improvement. Regularly updating the AI models based on new data and insights will ensure that the system remains adaptive to evolving insect threat scenarios.

13.Appendix

- AI: Artificial intelligence

- AI model: A computer program that uses AI to make predictions or decisions

- Crop health: The overall well-being of a crop, as measured by factors such as growth, yield, and resistance to pests and diseases

- Data mining: The process of extracting patterns and insights from data

- Deep learning: A type of machine learning that uses artificial neural networks to learn from data

- Farmer adoption: The process by which farmers adopt new technologies, such as AI-enabled prognostication

- Feature engineering: The process of transforming data into a format that can be used by AI models

- Historical data: Data that has been collected in the past
-
- Image analysis: The process of extracting information from images

- Insect threat: The potential for an insect to damage a crop
-
- Machine learning: A type of AI that allows computers to learn from data without being explicitly programmed

- Model performance: The accuracy of an AI model

- Model training: The process of teaching an AI model to make predictions or decisions

- Pest management: The process of controlling or preventing pests
- Precision agriculture: The use of technology to improve the efficiency and sustainability of agriculture
- Prognostication: The process of making predictions about future events
- Yield: The amount of crop produced per unit of land

Source Code : https://github.com/smartinternz02/SI-GuidedProject-611637-1700368667

Demonstration Link :
https://drive.google.com/file/d/1ImKA9Ove_yYsgW3XuwBIC58aICoNpXJY/view?usp=drive_link