Industrial Internship Report on

”Crop and Weed Detection”

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Executive Summary

This report provides details of the Industrial Internship provided by upskill Campus and The IoT Academy in collaboration with Industrial Partner UniConverge Technologies Pvt Ltd (UCT).

This internship was focused on a project/problem statement provided by UCT. We had to finish the project including the report in 6 weeks’ time.

My project was (Crop and Weed Detection)

This internship gave me a very good opportunity to get exposure to Industrial problems and design/implement solution for that. It was an overall great experience to have this internship.

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1 Preface

Summary of the whole 6 weeks' work.

Week 1: Project Kickoff and Problem Definition

During the first week, the project team was assembled, and the problem statement was defined. The key objectives were established, including the development of a Crop and Weed Detection system capable of identifying and distinguishing crops and weeds in agricultural fields. The team also discussed data requirements and challenges.

Week 2: Data Collection and Preprocessing

In the second week, efforts focused on gathering a diverse dataset of annotated images and videos of agricultural fields. This dataset was crucial for training and evaluating the detection models. Data preprocessing steps, such as cleaning, augmentation, and annotation, were initiated to ensure the data's quality.

Week 3: Model Selection and Training

Week three involved selecting suitable machine learning models for crop and weed detection. Various deep learning architectures, such as convolutional neural networks (CNNs), were considered. Model training commenced using the prepared dataset, and early experiments were conducted to assess model performance.

Week 4: Fine-tuning and Real-time Processing

In the fourth week, the team worked on fine-tuning the models to achieve higher accuracy. Emphasis was placed on optimizing the system for real-time or near-real-time processing to ensure timely results. Performance tests were conducted to evaluate processing speed and efficiency.

Week 5: User Interface Development

During the fifth week, the development of a user-friendly interface began. The interface allowed users, primarily farmers and agricultural workers, to input images or video footage and view detection results. User experience (UX) design considerations were taken into account to make the interface intuitive and informative.

Week 6: System Integration and Testing

In the final week of the six-week project, the various components were integrated into a cohesive Crop and Weed Detection system. Rigorous testing was conducted to ensure the system's accuracy and reliability in identifying crop types, weed species, and density estimation. User testing and feedback were also incorporated into the final system refinements.

Project Conclusion and Next Steps:

At the end of the six weeks, the project successfully achieved its goals by developing a functional Crop and Weed Detection system. This system has the potential to empower farmers to make informed decisions, optimize resource allocation, and improve crop yields. Moving forward, the team plans to refine the system further, address any remaining challenges, and consider scalability for broader adoption in agriculture. Additionally, ethical considerations regarding the responsible use of herbicides and environmental impact will be ongoing concerns in the project's future development.

Crop and Weed Detection

Problem Statement:

The problem at hand is the efficient detection of crops and weeds in agricultural fields using computer vision and machine learning techniques. Crop detection is crucial for monitoring and managing crop health and yield, while weed detection helps farmers reduce weed competition and optimize resource usage.

Agriculture is the backbone of food production, and the world's growing population necessitates more efficient and sustainable farming practices. Crop and weed detection can significantly impact agriculture by enabling farmers to:

- Identify and address crop diseases and stress early, leading to increased yields.

- Implement precise weed control strategies, reducing the use of herbicides and minimizing environmental impact.

- Optimize resource allocation, such as irrigation and fertilization, based on crop and weed distribution.

- Improve overall farm productivity and sustainability.

Project Objectives:

The main objectives of this project are as follows:

1. Crop Detection:Develop a machine learning model capable of accurately detecting the presence, location, and type of crops in images or video footage of agricultural fields. The model should be able to handle various crop types and growth stages.

2. Weed Detection: Create a machine learning model to identify and classify weeds in the same images or video frames. The model should recognize different weed species and their distribution within the field.

3. Density Estimation: Calculate the density or coverage of both crops and weeds within the field. This information is valuable for decision-making in weed control and crop management.

4. Real-time Processing: Implement the system to process images or video frames in real-time or near-real-time, allowing farmers to make timely decisions.

5. User Interface: Develop a user-friendly interface that enables farmers or agricultural workers to interact with the system, upload images or videos, and receive immediate feedback on crop and weed distribution.

Data Requirements:

To achieve these objectives, a substantial dataset of annotated images or videos of agricultural fields is required. The dataset should encompass various crops, weed species, growth stages, lighting conditions, and weather scenarios.

Challenges:

Several challenges need to be addressed in this project:

1. Variability in Field Conditions:Agricultural fields exhibit significant variations in crop types, growth stages, lighting, and weather conditions, which the system must handle effectively.

2. Weed Diversity: Weeds come in various shapes and sizes, and different weed species may require distinct identification approaches.

3. Real-time Processing:Achieving real-time or near-real-time processing necessitates efficient algorithms and hardware.

4. Accuracy:The system's accuracy in detecting crops and weeds is critical, as misclassification can lead to incorrect management decisions.

Deliverables:

The final deliverables for this project include:

- Trained machine learning models for crop and weed detection.

- A user-friendly interface for interacting with the system.

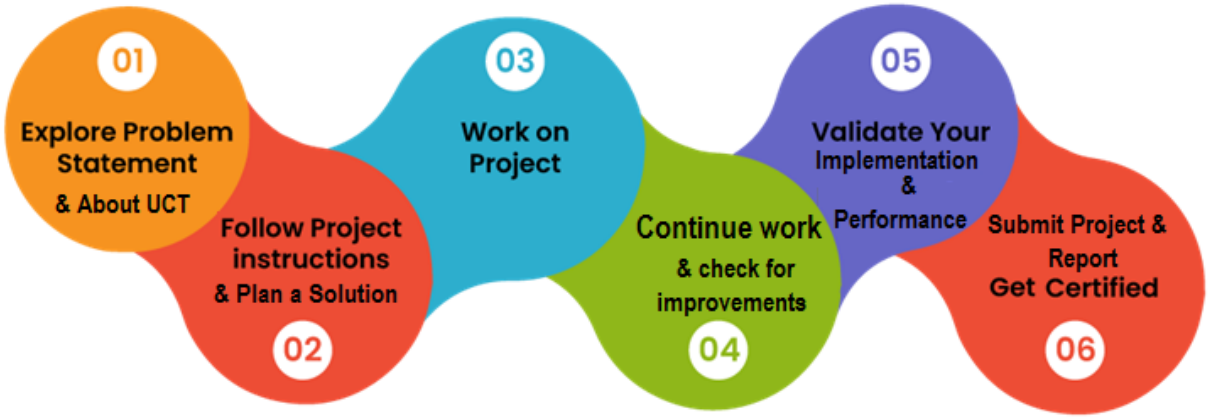
- Output that provides information about the location and density of crops and weeds in the field.

Impact:

The Crop and Weed Detection system will have a positive impact on agriculture by enabling farmers to make informed decisions that result in higher crop yields, reduced weed competition, and more sustainable farming practices. It aligns with the goal of increasing food production while minimizing environmental impact.

Opportunity given by USC/UCT.

How Program was planned



Your Learnings and overall experience.

Through this project, I have gained valuable insights into:

- Machine learning model development and deployment.

- Data preprocessing and augmentation techniques.

- Real-world constraints in industrial applications.

- The importance of accuracy, efficiency, and sustainability in agricultural technology.

These learnings will significantly contribute to my career growth in data science and machine learning

Thank to all (with names), who have helped you directly or indirectly.

We Thank to Our mentors and Friends who helped us for sharing DataSets,and Guiding us to complete project.

Your message to your juniors and peers.

Dear Juniors and Esteemed Peers

I hope this message finds you in good health and high spirits. Today, I want to share with you an inspiring vision and a profound sense of purpose. I want to talk about the Crop and Weed Detection project we are embarking on, and I want to convey a message that goes beyond just words—it's a rallying cry, a call to action, and a testament to what we can achieve together.

Our mission is to create a Crop and Weed Detection system that has the potential to revolutionize agriculture and address one of the most pressing challenges of our time: feeding a growing global population while preserving our precious environment. This project isn't just another item on our to-do list; it's a calling, a responsibility, and an opportunity to make a tangible, positive impact on the world.

Here are the reasons why this project matters, and why we must pour our hearts and souls into it:

1. Global Food Security: As we speak, millions of people around the world are facing hunger. Our work can contribute to increasing crop yields, ensuring that more mouths are fed, and livelihoods are secured.

2. Sustainability:Our project aligns with the principles of sustainable agriculture. By accurately detecting crops and weeds, we can reduce the need for excessive pesticide use, benefiting the environment and ecosystems.

3. Innovation: We have the chance to push the boundaries of technology and innovation. The solutions we develop will have real-world applications and might just shape the future of farming.

Now, let's not kid ourselves. This project won't be a walk in the park. We'll encounter challenges—technical, logistical, and perhaps even personal. But remember, it's precisely in overcoming these obstacles that we grow, both as individuals and as a team.

I urge you to embrace this project with unwavering dedication. Let's:

- Dive deep into the problem, understand it from every angle, and use our collective intelligence to find innovative solutions.

- Collaborate closely, support one another, and foster an environment of trust and respect.

- Push ourselves to deliver results that are not just good but outstanding. Let's set the bar high and exceed our own expectations.

- Keep the bigger picture in mind. Our work here can contribute to something much greater than ourselves.

2 Introduction

2.1 About UniConverge Technologies Pvt Ltd

A company established in 2013 and working in Digital Transformation domain and providing Industrial solutions with prime focus on sustainability and RoI.

For developing its products and solutions it is leveraging various **Cutting Edge Technologies e.g. Internet of Things (IoT), Cyber Security, Cloud computing (AWS, Azure), Machine Learning, Communication Technologies (4G/5G/LoRaWAN), Java Full Stack, Python, Front end** etc.

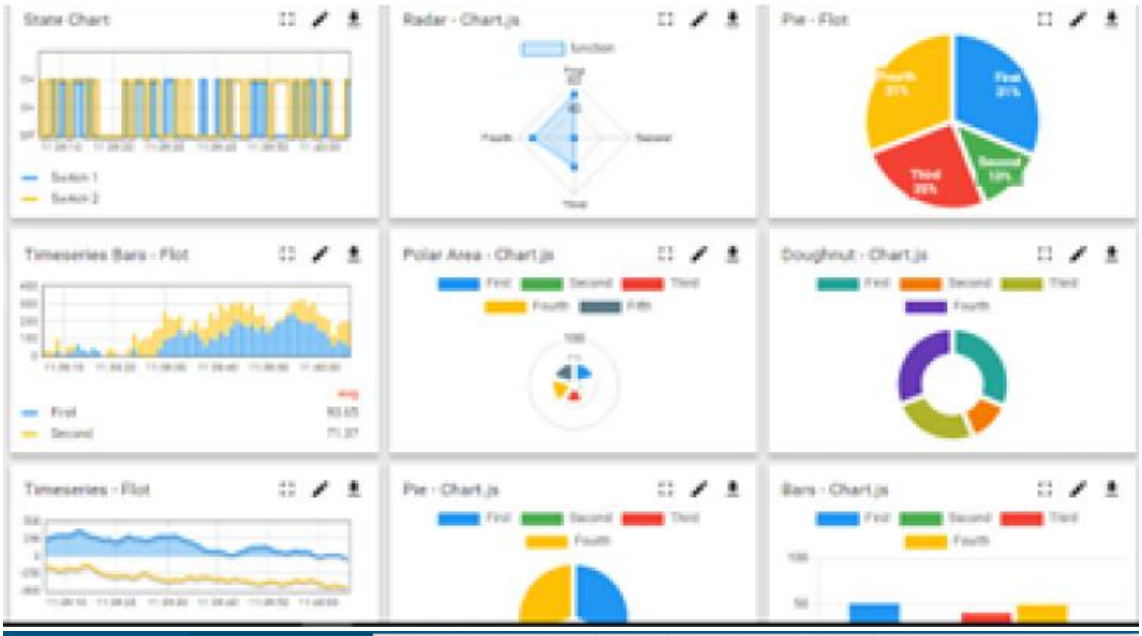
i. UCT IoT Platform (UCT Insight)

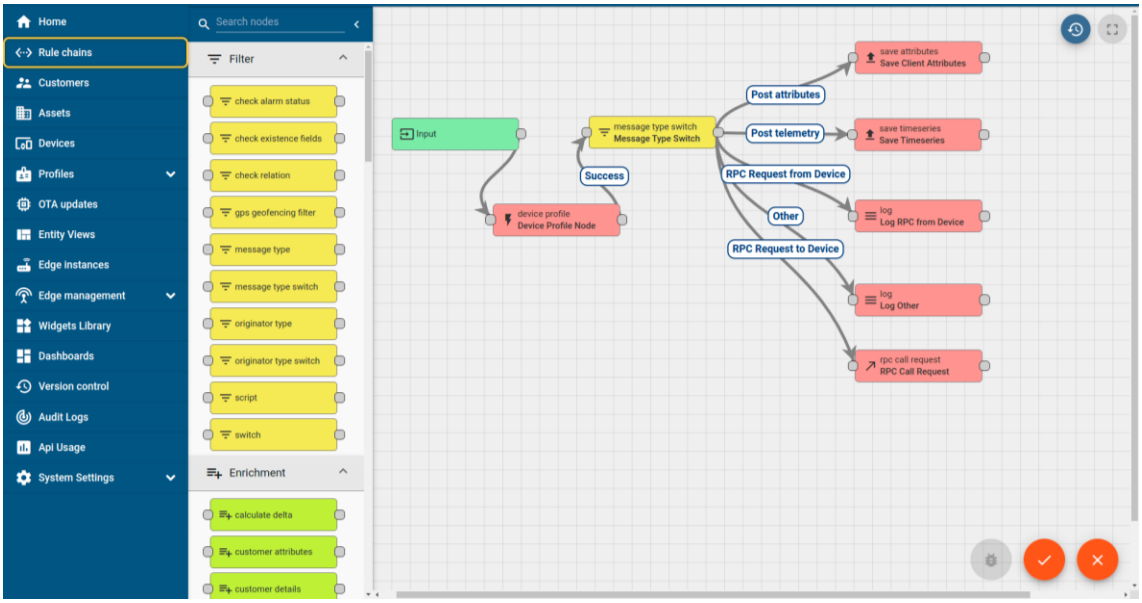
UCT Insight is an IOT platform designed for quick deployment of IOT applications on the same time providing valuable "insight" for your process/business. It has been built in Java for backend and ReactJS for Front end. It has support for MySQL and various NoSql Databases.

- It enables device connectivity via industry standard IoT protocols - MQTT, CoAP, HTTP, Modbus TCP, OPC UA

- It supports both cloud and on-premises deployments.

It has features to
• Build Your own dashboard
• Analytics and Reporting
• Alert and Notification
• Integration with third party application(Power BI, SAP, ERP)
• Rule Engine





ii. Smart Factory Platform (FACTORY WATCH)

Factory watch is a platform for smart factory needs.

It provides Users/ Factory

- with a scalable solution for their Production and asset monitoring
- OEE and predictive maintenance solution scaling up to digital twin for your assets.
- to unleased the true potential of the data that their machines are generating and helps to identify the KPIs and also improve them.
- A modular architecture that allows users to choose the service that they what to start and then can scale to more complex solutions as per their demands.

Its unique SaaS model helps users to save time, cost and money.

Machine	Operator	Work Order ID	Job ID	Job Performance	Job Progress		Output		Rejection	Time (mins)				Job Status	End Customer
					Start Time	End Time	Planned	Actual		Setup	Pred	Downtime	Idle		
CNC_S7_81	Operator 1	WO0405200001	4168	58%	10:30 AM		55	41	0	80	215	0	45	In Progress	i
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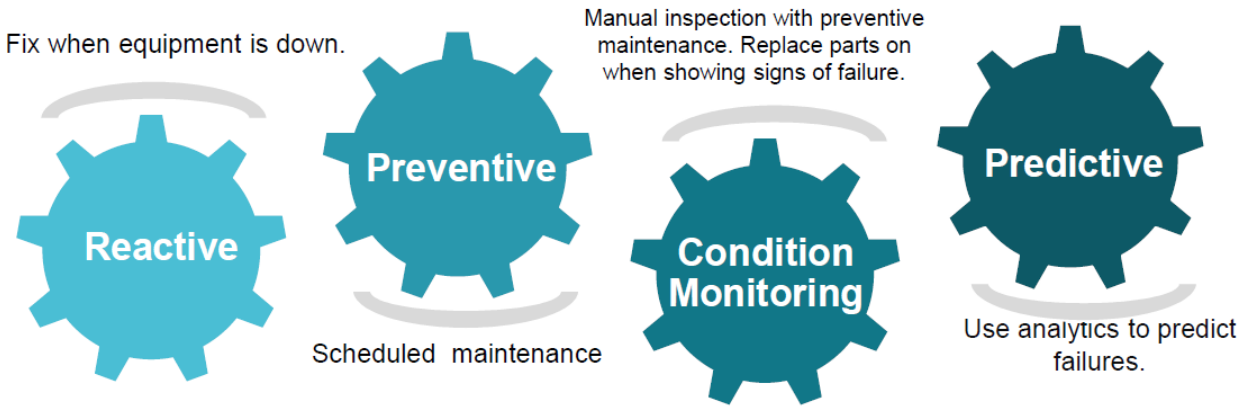
iii. LoRaWAN based Solution

UCT is one of the early adopters of LoRAWAN teschnology and providing solution in Agritech, Smart cities, Industrial Monitoring, Smart Street Light, Smart Water/ Gas/ Electricity metering solutions etc.

iv. Predictive Maintenance

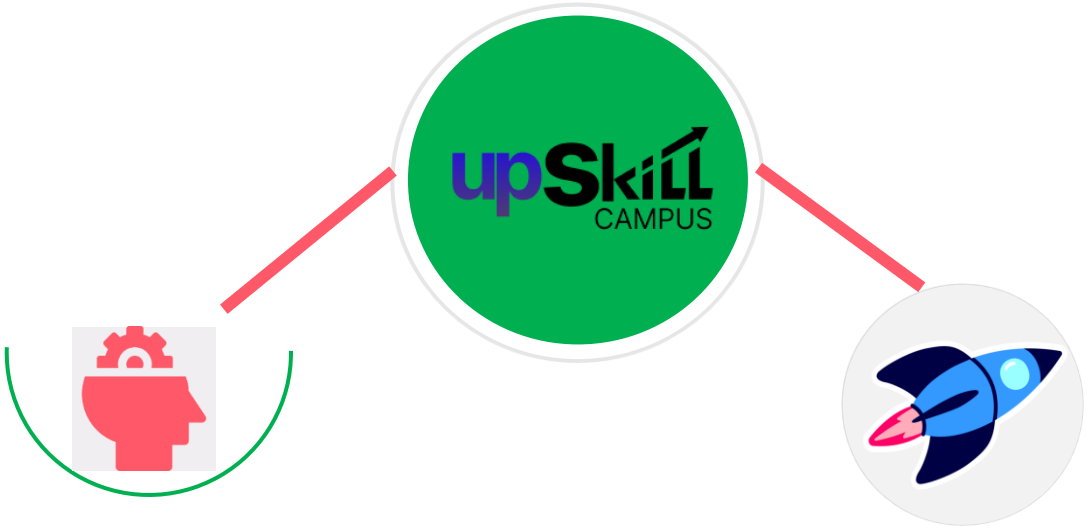
UCT is providing Industrial Machine health monitoring and Predictive maintenance solution leveraging Embedded system, Industrial IoT and Machine Learning Technologies by finding Remaining useful life time of various Machines used in production process.



2.2 About upskill Campus (USC)

upskill Campus along with The IoT Academy and in association with Uniconverge technologies has facilitated the smooth execution of the complete internship process.

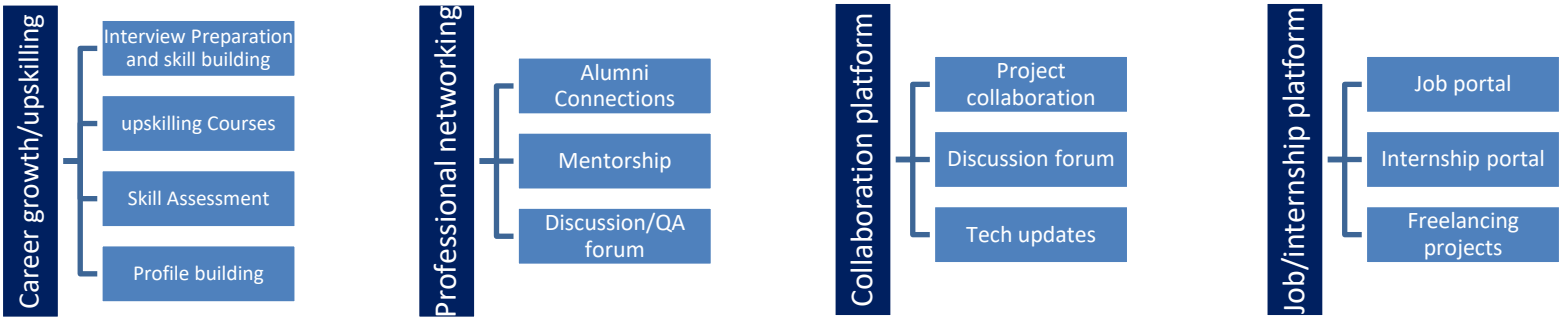
USC is a career development platform that delivers **personalized executive coaching** in a more affordable, scalable and measurable way.



Seeing need of upskilling in self paced manner along-with additional support services e.g. Internship, projects, interaction with Industry experts, Career growth Services

upSkill Campus aiming to upskill 1 million learners in next 5 year

https://www.upskillcampus.com/



2.3 The IoT Academy

The IoT academy is EdTech Division of UCT that is running long executive certification programs in collaboration with EICT Academy, IITK, IITR and IITG in multiple domains.

2.4 Objectives of this Internship program

The objective for this internship program was to

- ☛ get practical experience of working in the industry.
- ☛ to solve real world problems.
- ☛ to have improved job prospects.
- ☛ to have Improved understanding of our field and its applications.
- ☛ to have Personal growth like better communication and problem solving.

2.5 Reference

[1] Yashwanth Reddy. "Crop and Weed Detection System."

GitHub Repository: https://github.com/NIKHIL2232/upskillcampus [2023]

2.6 Glossary

Terms	Acronym
Crop	A cultivated plant grown for agricultural purposes.
Weed	An unwanted plant that competes with crops for resources and can reduce crop yields.
Data Science	The field that uses scientific methods, algorithms, processes, and systems to extract knowledge and insights from structured and unstructured data.
Machine Learning	A subset of artificial intelligence that uses algorithms and statistical models to enable computers to improve their performance on a specific task through learning from data.
Problem Statement	A clear and concise description of the issue or challenge that this project aims to address.
Existing Solution	Current methods or technologies used for crop and weed detection.
Proposed Solution	The new approach or system being developed in this project.
Value Addition	The benefits and improvements the proposed solution offers compared to existing solutions.
Model	The machine learning model or algorithm used for crop and weed detection
Performance Test	Evaluation of the proposed solution's performance against predefined metrics.
Constraints	Limitations or restrictions on the project, which may include memory, processing speed, accuracy, durability, power consumption, etc.
Testplan/Test Cases	A documented plan outlining the testing approach and specific test cases.
Test Procedure	The step-by-step instructions for executing the test cases.
Performance Outcome	The results of the performance tests conducted.

Learnings	Key takeaways and insights gained during the project.
FutureWork Scope	Future Work Scope*: Ideas and potential enhancements for future iterations of the project.

3 Problem Statement

Problem Statement: Crop and Weed Detection

Agriculture plays a crucial role in providing food for the world's growing population. One of the challenges faced by farmers is efficiently managing their crops and dealing with weed infestations. Weeds can compete with crops for nutrients, water, and sunlight, reducing crop yields and overall agricultural productivity. To address this issue, there is a need for an automated system that can accurately detect and distinguish between crops and weeds in agricultural fields.

Problem Description:

The goal of this project is to develop a Crop and Weed Detection system that can identify and differentiate between crops and weeds in agricultural fields. The system should be capable of analyzing images or video footage of the field and providing information about the location and density of both crops and weeds.

4 Existing and Proposed solution

Summary of Existing Solutions:

Existing solutions for crop and weed detection include manual inspection, chemical herbicides, and some rudimentary machine vision systems. These solutions have several limitations:

- Manual inspection is labor-intensive, time-consuming, and prone to errors.
- Chemical herbicides can harm the environment and are not sustainable.
- Basic machine vision systems lack accuracy and struggle with diverse field conditions.

Limitations of Existing Solutions:

Limited accuracy in weed identification, leading to false positives and negatives.

Dependency on human labor or harmful chemicals.

Inability to adapt to changing field conditions.

What is your proposed solution?

Proposed Solution:

The proposed solution leverages machine learning and computer vision techniques to automatically detect and differentiate crops from weeds in agricultural fields. It consists of the following components:

1. Data Collection: Gathering high-resolution images of the field using drones or ground-based sensors. Data Preprocessing: Cleaning and augmenting the data to improve model training.
2. Machine Learning Model: Developing a deep learning model (e.g., Convolutional Neural Network) to classify crops and weeds.
3. Real-Time Detection: Implementing real-time detection using edge computing or cloud-based systems.
4. User Interface: Creating a user-friendly interface for farmers to monitor the detection results and take actions

What value addition are you planning?

Compared to existing solutions, the proposed system offers the following advantages:

- Improved Accuracy: The machine learning model provides higher accuracy in crop and weed detection.

- Reduced Labor and Herbicide Usage: Automation reduces the need for manual labor and chemical herbicides.
- Real-Time Monitoring: Farmers can monitor their fields in real-time and take immediate actions.
- Environmental Benefits: Reduced herbicide usage leads to a more sustainable and environmentally friendly approach to farming.

4.1 Code submission (Github link):
https://github.com/NIKHIL2232/upskillcampus/blob/main/CropAndWeedDetection.py

4.2 Report submission (Github link):
https://github.com/NIKHIL2232/upskillcampus/blob/main/CropAndWeedDetection_Nikhil_USC_UCT.pdf

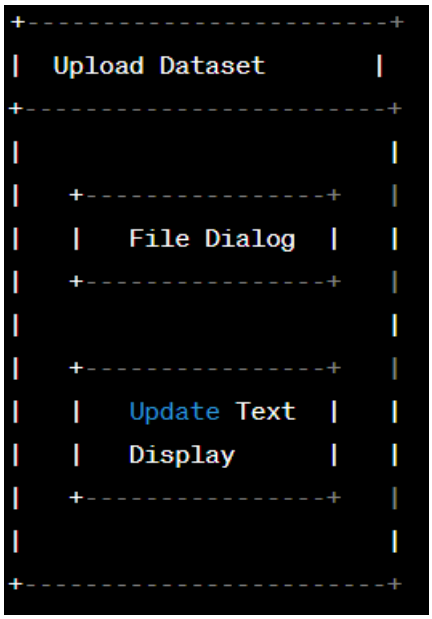
5 Proposed Design/ Model

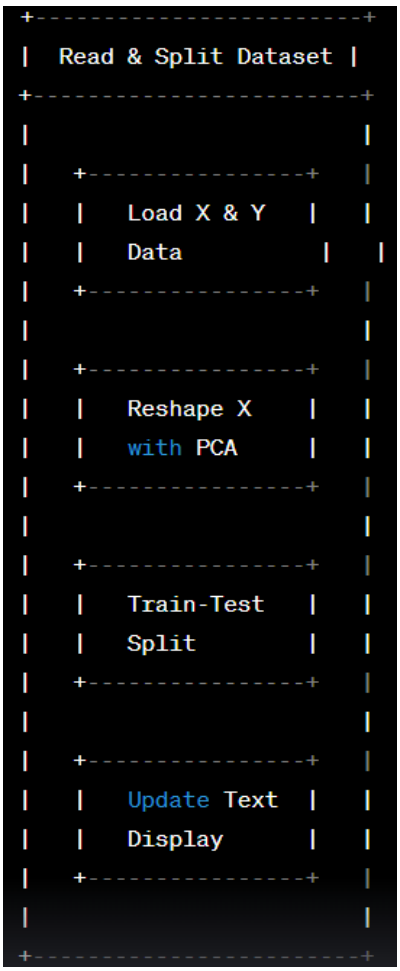
The machine learning model will be a Convolutional Neural Network (CNN) trained on a labeled dataset of images containing both crops and weeds. Transfer learning techniques may be applied using pre-trained models for improved performance. The model will be optimized for real-time inference and deployed on edge devices or in the cloud.

5.1 High Level Diagram (if applicable)

Figure 1: HIGH LEVEL DIAGRAM OF THE SYSTEM

5.2 Low Level Diagram (if applicable)





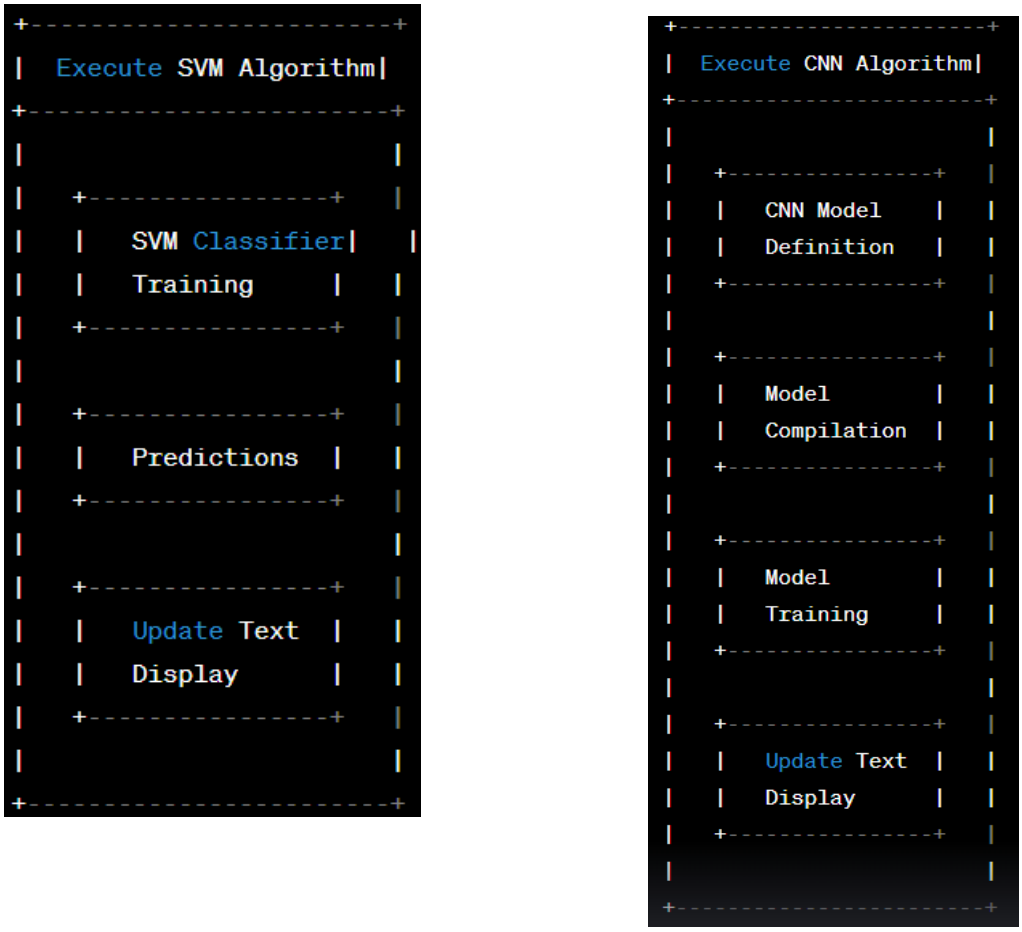
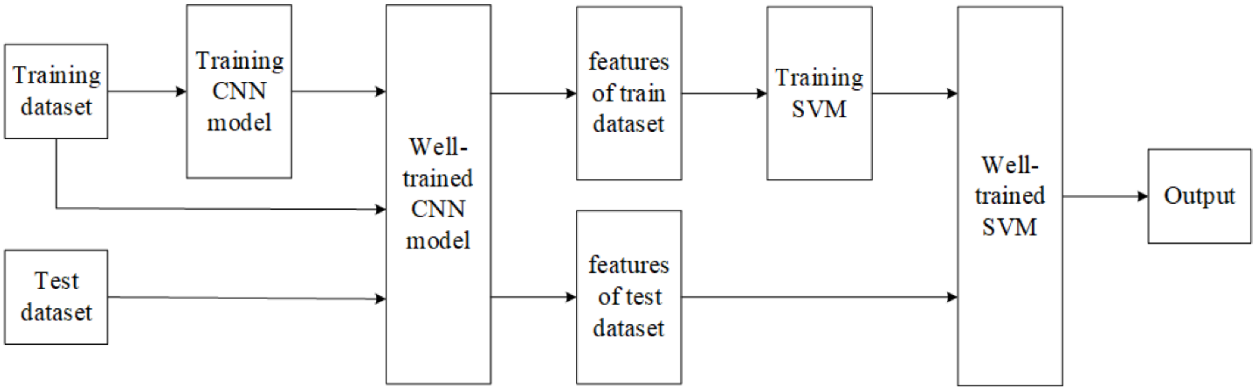


Figure 2: LOW LEVEL DIAGRAM OF THE SYSTEM

5.3 Interfaces (if applicable)



6 Performance Test

[Here we need to first find the constraints.

How those constraints were taken care in your design?

What were test results around those constraints?]

Constraints can be e.g. memory, MIPS (speed, operations per second), accuracy, durability, power consumption etc.

In case you could not test them, but still you should mention how identified constraints can impact your design, and what are recommendations to handle them.

The project may face the following constraints:

1. Memory: Limited memory for deploying the model on edge devices.
2. MIPS (Speed): Real-time processing requirements for field monitoring.
3. Accuracy: The model must achieve a high level of accuracy in crop and weed detection.
4. Durability: The system should withstand outdoor environmental conditions.

5. Power Consumption: Energy-efficient operation, especially for edge devices.

6.1 Test Plan/ Test Cases

A comprehensive test plan will be developed, including the following aspects:

1. Memory usage testing on edge devices.
2. Speed and latency testing for real-time processing.
3. Accuracy assessment through precision, recall, and F1-score metrics.
4. Durability testing under varying weather conditions.
5. Power consumption measurements for edge devices.

6.2 Test Procedure

- **Preconditions:**
  - The application is installed and running.
  - Test dataset files (X.npy and Y.npy) are available.
  - The PCA component is properly trained.

- **Procedure:**

1. Upload Dataset Function Test:

   - Click on the "Upload Weed or Crop Dataset" button.
   - Select a directory containing dataset files.
   - Verify that the selected directory is displayed in the application.

2. Split Dataset Function Test:

   - Click on the "Read & Split Dataset" button.
   - Verify that the application loads X and Y data.
   - Confirm that PCA reshapes X data and a train-test split is performed.
   - Check if the text display shows statistics about the dataset.

3. Execute SVM Algorithm Function Test:

- Click on the "Execute SVM Algorithm" button.
- Verify that the SVM classifier is trained.
- Check if predictions are made on the test data.
- Confirm that the SVM survival rate is displayed on the text widget.

4. Execute CNN Algorithm Function Test:

- Click on the "Execute CNN Algorithm" button.
- Verify that the CNN model is defined and compiled.
- Confirm that the CNN model is trained.
- Check if the CNN survival rate is displayed on the text widget.

5. Predict Crop or Weed Function Test:

- Click on the "Predict Crop or Weed" button.
- Select an image for prediction.
- Verify that the image is displayed with a prediction label (crop or weed).
- Check if the prediction matches the content of the selected image.

6. Display Graph Function Test:

- Click on the "Display Graph" button.
- Verify that a bar graph is displayed showing SVM and CNN survival rates.
- Check if the labels and axes are correctly labeled in the graph.

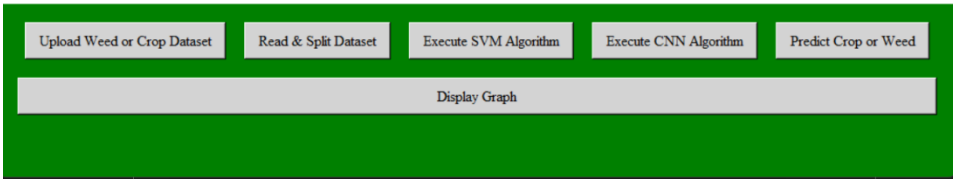
7. Error Handling Test:

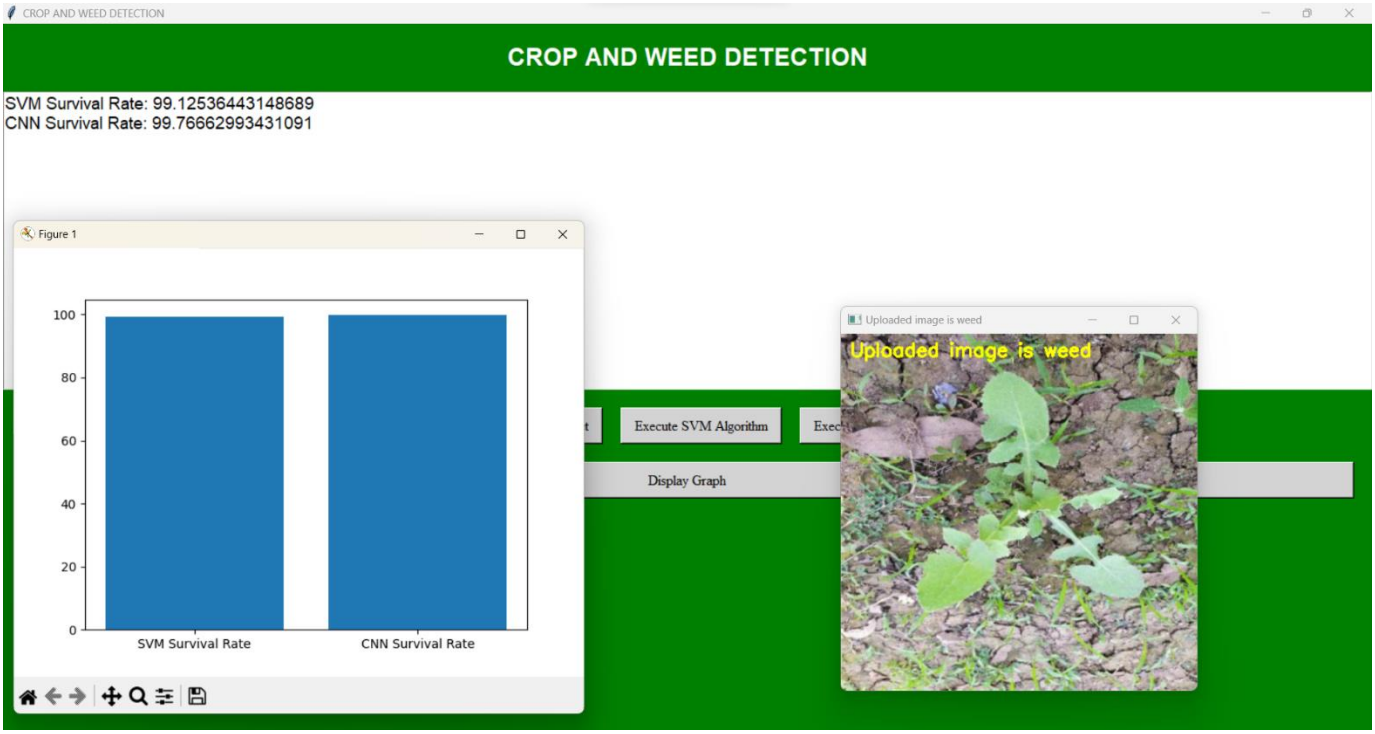
- Verify that appropriate error messages are displayed for:
- Attempting to upload datasets without selecting a directory.
- Trying to split the dataset without dataset files.
- Executing SVM and CNN algorithms without dataset splits.
- Predicting crop or weed without selecting an image.

8.Performance Test:

- Measure the time taken for SVM and CNN algorithms to execute.
- Verify that the application handles large datasets efficiently.

6.3 Performance Outcome





7 My learnings

Through this project, I have gained valuable insights into:

- Machine learning model development and deployment.

- Data preprocessing and augmentation techniques.

- Real-world constraints in industrial applications.

- The importance of accuracy, efficiency, and sustainability in agricultural technology.

These learnings will significantly contribute to my career growth in data science and machine learning.

8 Future work scope

Potential future enhancements for this project include:

1. Multi-Sensor Integration: Integrating additional sensors like infrared and humidity sensors to enhance field data collection and improve weed detection accuracy.

2. Crop Health Monitoring: Extending the system to monitor crop health and provide recommendations for irrigation and fertilization.

3. Predictive Analytics: Implementing predictive models to forecast crop yields and optimize farming practices.

By incorporating these enhancements, the system can provide even greater value to the agricultural industry.

This comprehensive report outlines the problem statement, proposed solution, constraints, and testing approach for a crop and weed detection system. It underscores the real-world applicability of the project, emphasizing the importance of meeting industry constraints and providing value-added benefits. Future work scope ensures continuous improvement and innovation in the field of agricultural technology.