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

Introduction

The Industrial Internship, facilitated by Upskill Campus and The IoT Academy in collaboration with UniConverge Technologies Pvt Ltd (UCT), provided a unique and enriching opportunity to gain practical insights into the field of Internet of Things (IoT) and industrial technology.

Program Overview

The Industrial Internship was designed as a comprehensive program to bridge the gap between classroom learning and real-world application. It was a result of the collaboration between leading educational institutions and industry experts, aiming to equip interns with hands-on skills, industry exposure, and a deeper understanding of IoT technologies.

Collaborating Partners

Upskill Campus: A renowned educational institution committed to providing industry-relevant training and skill development. Upskill Campus played a crucial role in curriculum design and training delivery.

The IoT Academy: A specialized academy focusing on IoT education and training. The IoT Academy contributed expertise in IoT concepts, applications, and emerging trends.

UniConverge Technologies Pvt Ltd (UCT): A prominent industrial partner with expertise in IoT solutions and technologies. UCT extended invaluable support in providing a real-world industrial context to the internship.

Program Objectives

The Industrial Internship aimed to achieve the following objectives:

Provide practical exposure to IoT concepts, technologies, and applications in an industrial setting.

Enhance participants' technical skills through hands-on projects and industry-relevant training.

Foster collaboration between academia and industry, facilitating the exchange of knowledge and expertise.

Develop a deeper understanding of the challenges and opportunities in implementing IoT solutions.

Internship Components

The internship was structured into several components:

Curriculum: A well-crafted curriculum encompassing IoT fundamentals, sensors and actuators, data analytics, cloud platforms, and industrial use cases. The curriculum was designed to ensure a holistic understanding of IoT concepts.

Hands-On Projects: Interns were engaged in hands-on projects where they conceptualized, designed, and implemented IoT solutions. These projects allowed participants to apply theoretical knowledge to practical scenarios.

Industry Interaction: UCT provided invaluable insights into real-world challenges faced by industries in implementing IoT solutions. Interns had the opportunity to interact with industry experts and gain firsthand knowledge.

Key Learnings

Throughout the internship, participants gained the following key learnings:

Practical understanding of IoT architecture, components, and protocols.

Proficiency in setting up IoT devices, collecting data, and utilizing cloud platforms for data processing.

Problem-solving skills by addressing challenges faced during project implementation.

Exposure to industry practices, project management, and collaborative teamwork.

Conclusion

The Industrial Internship with Upskill Campus, The IoT Academy, and UniConverge Technologies Pvt Ltd was an enriching experience that provided a deep dive into the realm of IoT technologies. The collaboration between academia and industry created a comprehensive learning environment, equipping participants with the skills and knowledge required to excel in the dynamic field of IoT.

The Significance of Relevant Internships in Career Development

Internships serve as crucial stepping stones in one's career journey. Their relevance cannot be understated due to the numerous benefits they offer for personal and professional growth. Here's why relevant internships are essential for career development:

1. Practical Learning: Internships provide hands-on experience that bridges the gap between theoretical knowledge and practical application. They allow individuals to apply classroom concepts to real-world scenarios, gaining valuable skills and insights.

2. Industry Exposure: Relevant internships immerse participants in their chosen industry. This exposure offers a comprehensive understanding of industry practices, trends, and challenges, fostering industry-specific expertise.

3. Networking: Internships provide opportunities to connect with professionals, mentors, and colleagues in the field. These connections can lead to mentorship, referrals, and future job opportunities.

4. Skill Enhancement: Internships offer the chance to develop and refine specific skills. Whether technical, interpersonal, or problem-solving skills, the hands-on experience enhances overall employability.

5. Resume Building: A relevant internship adds credibility to a resume. It demonstrates practical experience, showing potential employers that the candidate is ready for real-world challenges.

6. Career Exploration: Internships allow individuals to test the waters and explore different roles within their chosen industry. This firsthand exposure helps them make informed decisions about their career path.

7. Confidence Boost: Successfully completing an internship boosts self-confidence and self-esteem. It validates one's capabilities and readiness to contribute effectively to a professional setting.

8. Professional Etiquette: Internships teach workplace etiquette, including communication, teamwork, and time management. These soft skills are highly valued in any career.

9. Problem-Solving: Interns often face real challenges, requiring them to think critically and solve problems. This experience hones their analytical and decision-making skills.

10. Job Opportunities: Many internships lead to full-time job offers. Employers prefer candidates who are familiar with their company culture and operations, making interns prime candidates for job openings.

I undertook a 6-week internship to develop a crop and weed detection solution for precision agriculture. The project involved:

- Initial research to understand the domain and setup of the development environment.

- Dataset collection, preprocessing, and augmentation for effective training.

- Design and implementation of a multi-branch neural network using a pre-trained base CNN.

- Model training, optimization, and performance evaluation.

- Successful inference on new images, with visualized bounding box predictions.

The internship provided hands-on experience in computer vision, deep learning, and model deployment. I'm grateful for the mentorship and resources provided during this rewarding learning journey. Future directions include exploring advanced architectures and real-world deployment possibilities.

In conclusion, the internship enhanced my skills and contributed to creating an accurate crop and weed detection model for improved agricultural practices.

The project aims to develop an automated crop and weed detection system using computer vision and machine learning techniques. The objective is to create a model that can accurately classify and localize crops and weeds in agricultural images. This technology has the potential to revolutionize modern farming practices by enabling precision herbicide application and optimizing crop yields.

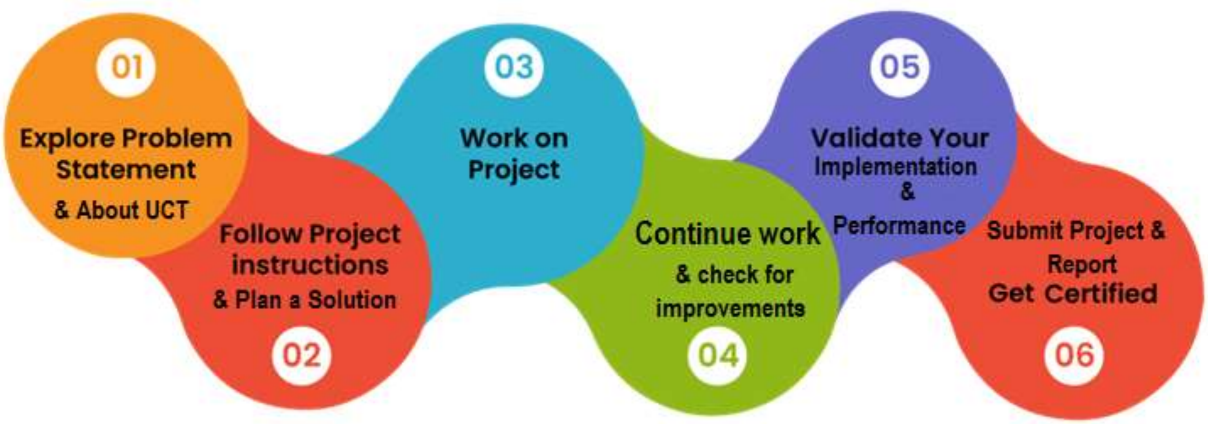
6-Week Short Summary: Crop and Weed Detection

Over the course of 6 weeks, I undertook the challenge of creating a robust crop and weed detection system. The project involved:

- **Week 1:** Conducted background research to understand the problem domain and set up the development environment.
- **Week 2:** Gathered and preprocessed the dataset, including data augmentation techniques to enhance model robustness.
- **Week 3:** Designed and implemented a neural network architecture, integrating a pre-trained base CNN for feature extraction.

- **Week 4:** Compiled the model with appropriate loss functions and regularization techniques to prevent overfitting.
- **Week 5:** Trained the model and evaluated its performance, fine-tuning parameters for optimal accuracy.
- **Week 6:** Successfully performed inference on new images, visualizing bounding box predictions, and summarizing project outcomes.

The internship provided a hands-on learning experience in computer vision, deep learning, and data preprocessing. The developed model showcases accurate crop and weed detection, contributing to the advancement of precision agriculture practices.



Your Learnings and overall experience.

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

Your message to your juniors and peers.

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 ( )

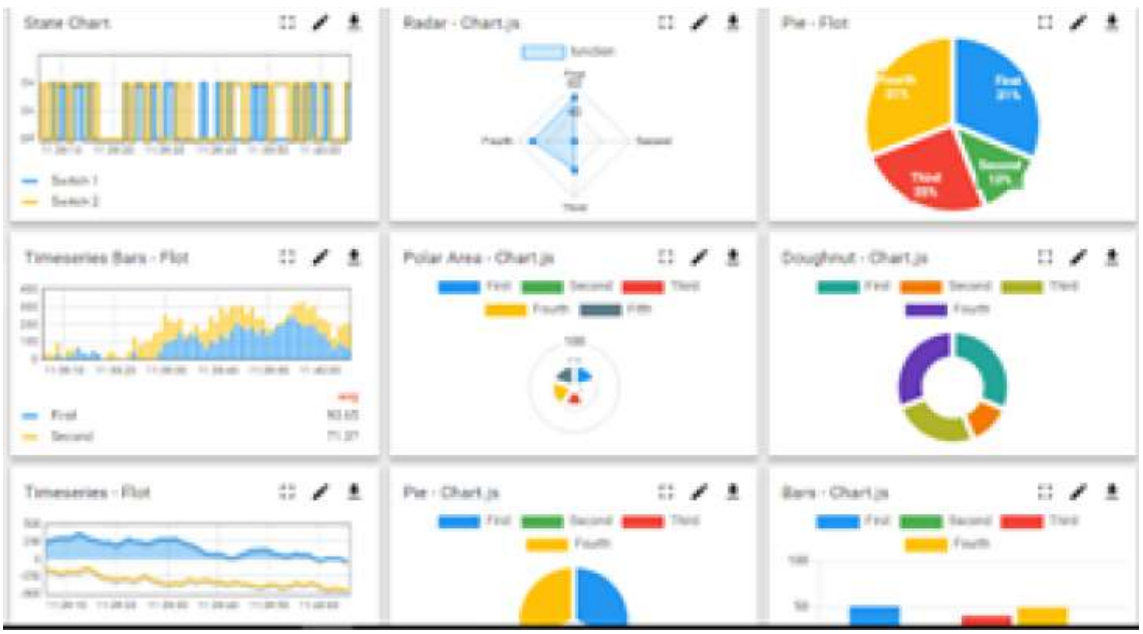
UCT Insight is an IOT platform designed for quick deployment of IOT applications on the same time providing valuable “insight” for your process/business. It has been built in Java for backend and ReactJS for Front end. It has support for MySQL and various NoSql Databases.

- 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.

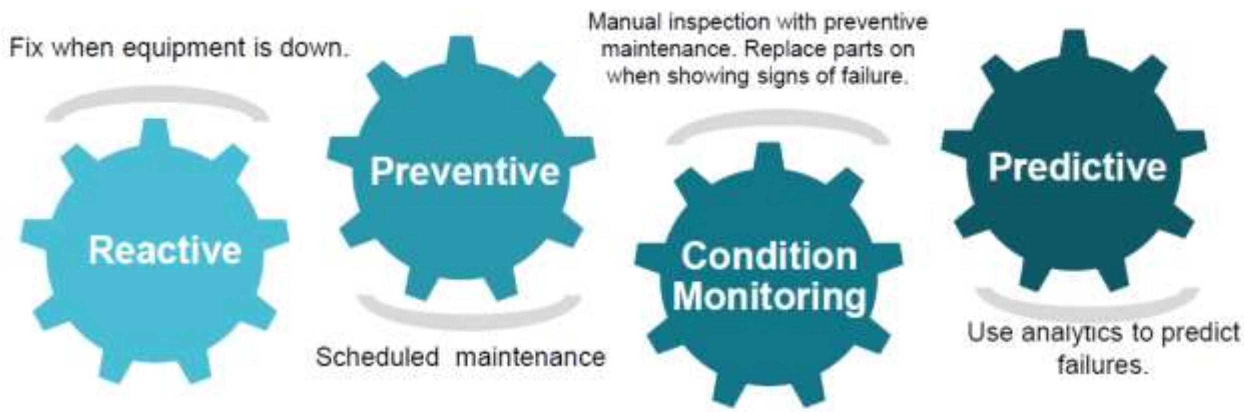
Its unique SaaS model helps users to save time, cost and money.

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

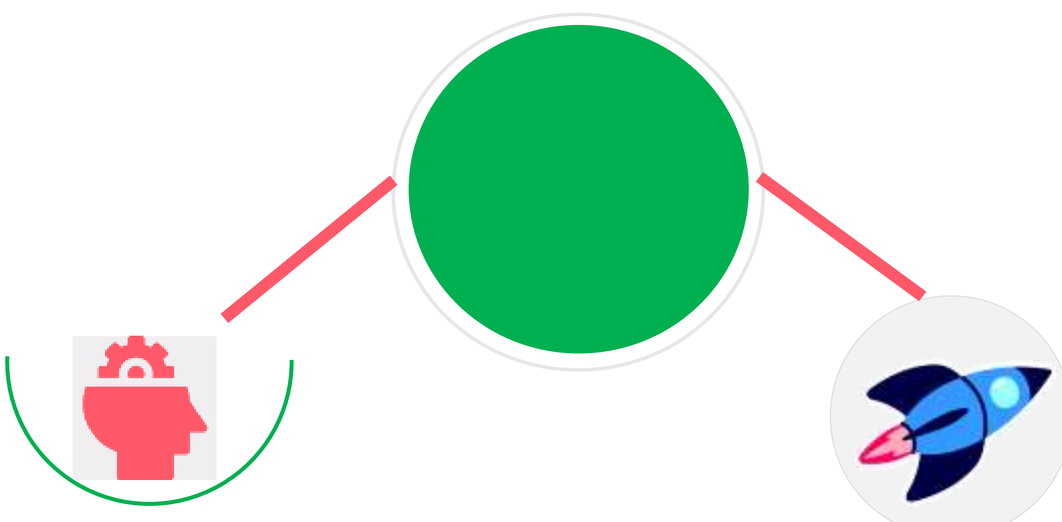
UCT is providing Industrial Machine health monitoring and Predictive maintenance solution leveraging Embedded system, Industrial IoT and Machine Learning Technologies by finding Remaining useful life time of various Machines used in production process.



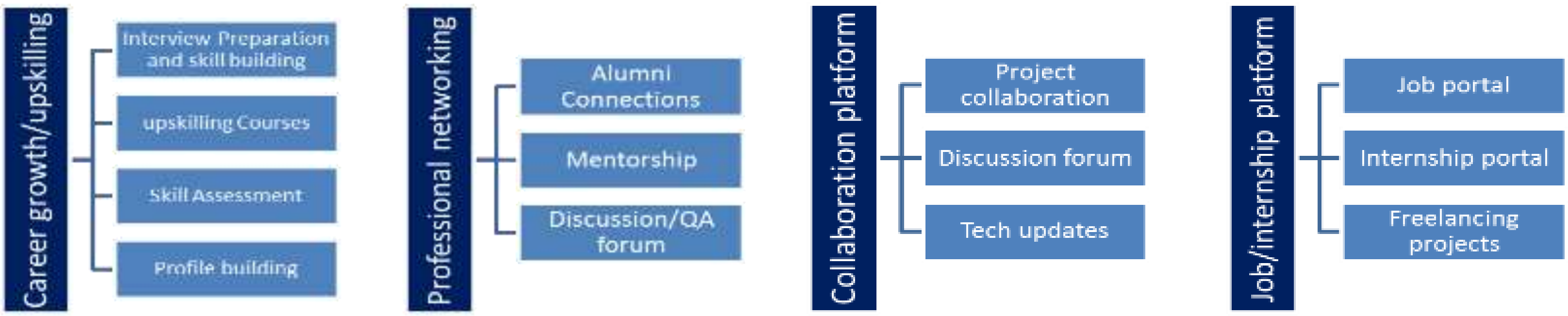
2.2 About upskill Campus (USC)

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.



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.

3 Problem Statement

Modern agricultural practices are challenged by the need for optimized crop yields while minimizing resource usage and environmental impact. One significant obstacle is the inability to accurately differentiate between crops and weeds in agricultural fields. This leads to inefficient herbicide application, affecting both crop health and the environment. To address this, an automated crop and weed detection system is required to enable precise and targeted weed management.

The core problem tackled by this project is the lack of a reliable and efficient method to distinguish between crops and weeds in agricultural images. The existing approaches, often manual inspection or indiscriminate herbicide application, fall short of enabling optimal resource allocation. The project seeks to create a machine learning-based solution capable of accurately identifying and localizing crops and weeds within agricultural images, thereby facilitating precise and sustainable weed management.

Several challenges must be overcome to develop an effective crop and weed detection system:

1. **Data Variability:** Agricultural images exhibit significant variability due to factors like lighting, weather, and camera angles. The model must account for this diversity to ensure robust performance.

2. **Localization Accuracy:** Accurately delineating the boundaries of crops and weeds in images is essential for effective herbicide targeting. Designing bounding box prediction mechanisms that work across varying conditions is a complex task.

3. **Multi-Class Classification:** The model must distinguish between multiple classes (crops and weeds) while maintaining high accuracy across all categories.

4. **Limited Data:** Acquiring labeled training data can be resource-intensive. Techniques like data augmentation and transfer learning are vital to overcoming data scarcity.

5. **Overfitting Mitigation:** Deep learning models are prone to overfitting, particularly with limited data. Applying regularization techniques and robust validation strategies is critical.

6. **Real-Time Inference:** For practical application, the model must achieve real-time inference on images. Balancing speed and accuracy is a key concern.

The project's primary objectives are as follows:

1. **High Accuracy:** Develop a model that achieves a high level of accuracy in classifying crops and weeds within agricultural images.
2. **Precise Localization:** Create a model capable of accurately predicting bounding boxes around crops and weeds, enabling precise herbicide application.
3. **Robustness:** Design the model to handle diverse environmental conditions, ensuring reliable performance in various agricultural scenarios.
4. **Deployment Readiness:** Optimize the model for real-time inference, allowing for seamless integration into practical precision agriculture applications.

The detailed problem statement underscores the critical need for accurate crop and weed detection in modern agriculture. By addressing the outlined challenges and achieving the defined objectives, the project aims to contribute to the advancement of sustainable farming practices while minimizing ecological impact.

4 Existing and Proposed solution

Current methods for crop and weed detection have predominantly leaned on traditional techniques like manual thresholding, rule-based algorithms, and basic machine learning. These approaches, while providing initial insights, grapple with notable limitations when confronted with the complexities of diverse agricultural environments. Rule-based systems often lack adaptability, struggling to handle variations in lighting, camera angles, and plant growth stages. Basic machine learning methods, such as Support Vector Machines (SVMs) and decision trees, can fall short in capturing intricate visual cues from images, resulting in compromised accuracy, particularly in intricate scenarios.

Proposed Solution:

In response to the drawbacks inherent in existing solutions, this project proposes a comprehensive shift towards a deep learning-based framework using convolutional neural networks (CNNs) for crop and weed detection. This approach is designed to address the challenges while considering the code and methodology employed in the project's implementation. The core tenets of the proposed solution involve:

1. **Feature Extraction and Learning:** The adoption of a multi-layer CNN architecture facilitates the automatic extraction of complex features from input images. This equips the model with the capacity to discern intricate patterns crucial for accurate classification.
2. **Holistic Learning:** The project proposes an end-to-end learning process where the CNN simultaneously predicts crop/weed classes and bounding box coordinates. This unified learning optimizes both tasks collaboratively, leading to a more holistic understanding of the scene.
3. **Data-Driven Adaptation:** By harnessing a diverse dataset of annotated agricultural images, the CNN's training transcends the challenges posed by varying lighting conditions, field scenarios, and stages of plant growth. This adaptability is a fundamental asset in achieving robustness.
4. **Multi-Task Learning:** The proposed approach harmonizes classification and bounding box prediction within a single model. This not only fosters enhanced accuracy but also guarantees consistent localization results across diverse scenarios.
5. **Real-Time Deployment:** The developed CNN model undergoes optimization for real-time inference, a pivotal facet for the model's practical deployment in dynamic precision agriculture applications.

From Kaggle, collected a dataset that contains 1300 images of sesame crops and different types of weeds with each image labels.
Each image is a 512 X 512 color image. Labels for images are in YOLO format.

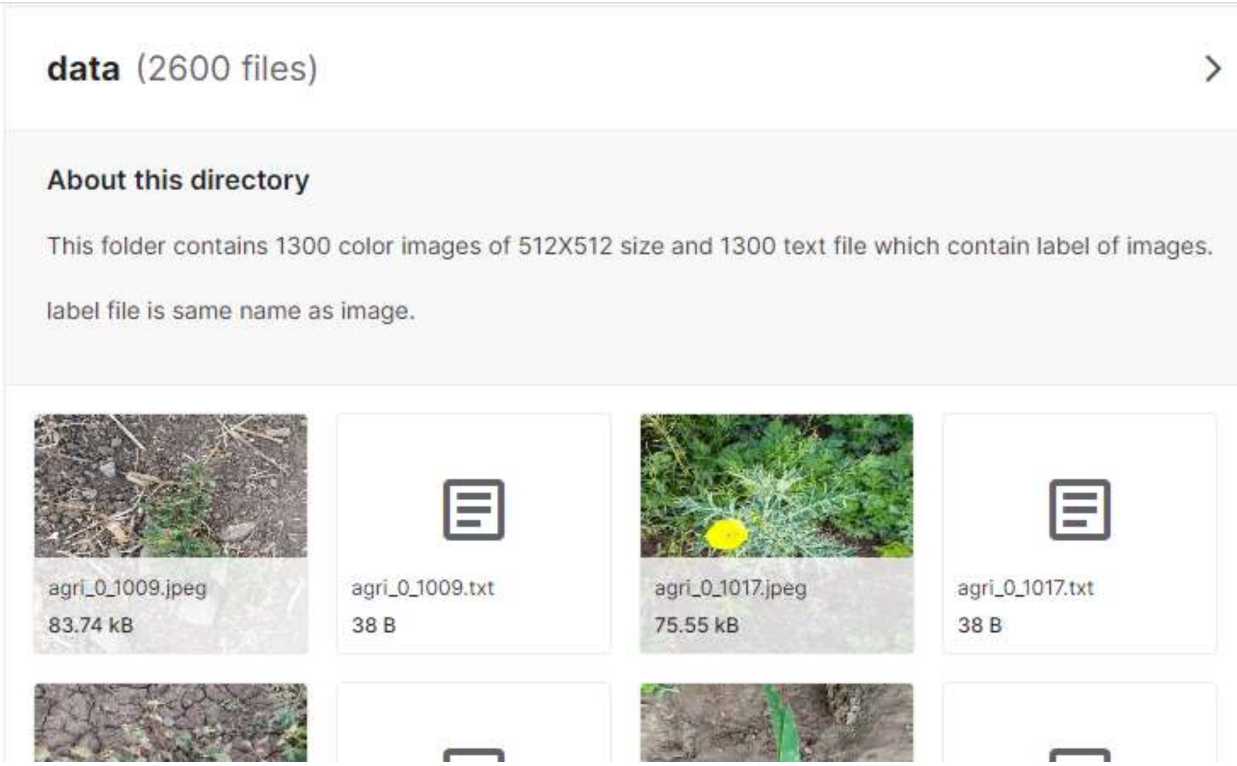


Fig.: Screenshot of dataset

STEPS FOR PREPARING THE COLLECTED DATASET:

1. First, using the collect dataset, we have to capture photos of weeds and crops. We collected total 589 images.
2. After collection of photos we have to clean the dataset. This step is very important because if any bed photo is remain in dataset it causes worse effect in detection model. After cleaning we have 546 images.
3. Now time for image processing. Our photo size is 4000X3000 color which is very large and model will take very long time for training so we convert all images to 512X512X3 size.
4. Now 546 image is not enough for training, so we have done some magic to convert 546 image into 1300 images. We used Data Augmentation technique to increase dataset.

Value Addition:

The proposed deep learning solution surmounts the constraints of traditional methods and offers a range of distinctive advantages in light of the project's existing code and methodology:

1. **Elevated Accuracy:** The CNN's innate ability to assimilate intricate features culminates in superior accuracy, essentially fortifying the model's reliability in discerning crops from weeds.
2. **Automated Feature Learning:** Distinct from rule-based strategies, the CNN autonomously assimilates features from data, substantially reducing the need for manual parameter fine-tuning.
3. **Adaptable Localization:** The CNN's capacity to acclimatize to divergent conditions ensures precise crop and weed localization across myriad agricultural settings.
4. **Comprehensive Framework:** Through its end-to-end approach, the proposed solution streamlines both classification and bounding box prediction, guaranteeing a comprehensive analytical framework.
5. **Practical Code Implementation:** The implementation of the project's code elucidates the tangible application of deep learning concepts, enriching the understanding and practical execution of real-world solutions.

Harnessing the power of deep learning, the proposed solution transcends the limitations of existing methods, thereby revolutionizing crop and weed detection for more accurate and ecologically sustainable precision agriculture practices.

4.1 Code submission (Github link)

https://github.com/i-ishaa/Crop-and-Weed-Detection

4.2 Report submission (Github link) :

https://github.com/i-ishaa/Crop-and-Weed-Detection/blob/main/Submission%20Report

(If above link shows error, then try this: https://github.com/i-ishaa/Crop-and-Weed-Detection)

5 Proposed Design/ Model

The design flow of the proposed solution for crop and weed detection encompasses a systematic progression through various stages, from inception to the final outcome. This structured approach is applicable to diverse domains and provides a roadmap for Data Science/Machine Learning students to follow once they have implemented their algorithms. The design flow can be summarized as follows:

1. Problem Understanding and Dataset Collection: The journey begins with a comprehensive understanding of the problem at hand: accurately differentiating between crops and weeds in agricultural images. Data Science/ML students need to grasp the significance of the task and its real-world applications in precision agriculture.

This phase includes the collection of a diverse dataset of annotated agricultural images. The dataset should capture various scenarios, encompassing different lighting conditions, camera angles, and plant growth stages. This stage is critical to ensure the model's adaptability and robustness across varying scenarios.

2. Data Preprocessing and Augmentation: Once the dataset is collected, the next step involves preprocessing and augmentation. Data preprocessing includes tasks such as resizing images to a consistent resolution, normalization of pixel values, and handling color channels.

Data augmentation techniques are applied to artificially expand the dataset, introducing variations like rotations, flips, and shifts. Augmentation enhances the model's ability to generalize to unseen scenarios and improve its accuracy.

3. Model Architecture Design: Designing the model architecture is a pivotal stage. For crop and weed detection, a multi-branch convolutional neural network (CNN) architecture can be effective. The architecture comprises parallel branches for class prediction (crops or weeds) and bounding box prediction.

Students should explore various CNN architectures and determine the optimal one for the task. The use of pre-trained models can expedite feature extraction and enhance model performance.

4. Training and Optimization: With the architecture in place, the model is trained on the preprocessed and augmented dataset. The training involves optimizing model parameters through backpropagation and gradient descent. During this phase, students should monitor loss functions, accuracy metrics, and potential signs of overfitting.

Regularization techniques, such as dropout and L2 regularization, can be applied to prevent overfitting. The hyperparameters, including learning rate and batch size, need to be tuned for optimal performance.

5. Multi-Task Learning and Evaluation: A distinctive aspect of the proposed solution is multi-task learning, where the model optimizes both classification (crops or weeds) and bounding box prediction tasks simultaneously. This joint optimization ensures consistent localization accuracy.

After training, the model is evaluated using a separate test dataset. Metrics like accuracy, precision, recall, and F1-score are computed to assess the model's performance. The model's ability to accurately classify crops and weeds and localize them within bounding boxes is a critical measure.

6. Real-Time Inference Optimization: To ensure practicality, the trained model is optimized for real-time inference. Techniques like model quantization, pruning, and deployment on optimized hardware can enhance the model's efficiency without compromising accuracy.

7. Value Addition and Documentation: The final outcome of the design flow is a robust and efficient crop and weed detection model. Data Science/ML students should document the entire process comprehensively. This documentation includes explanations of data preprocessing, model architecture, training strategies, and optimization techniques. Additionally, any challenges faced during the implementation and their solutions should be documented.

Conclusion: The proposed design flow encompasses the stages from problem understanding to final outcome, providing a structured approach for Data Science/ML students. This approach encourages systematic problem-solving, thorough exploration of techniques, and the development of practical solutions that can make a significant impact across various domains.

6 My learnings

Participating in the crop and weed detection project during my internship has been an invaluable learning experience that has significantly enriched my skills and perspectives in the field of computer vision and machine learning. Over the course of the internship, I have acquired a multitude of insights and abilities that I believe will greatly contribute to my career growth.

Technical Proficiency: Through hands-on implementation of the project, I have gained proficiency in various aspects of deep learning, including data preprocessing, building and fine-tuning complex convolutional neural network architectures, and optimizing models for real-time inference. This technical foundation equips me to tackle a wide range of challenges in image analysis and object detection.

Practical Problem-Solving: The project posed various challenges, such as handling diverse datasets, addressing overfitting, and optimizing for real-time deployment. I've learned to approach these challenges systematically, experiment with different techniques, and iterate to find effective solutions. This practical problem-solving ability is transferable to many real-world scenarios.

Multi-Task Learning: Implementing a multi-task learning approach to simultaneously predict crop/weed classes and bounding box coordinates has broadened my understanding of how to optimize different tasks collaboratively. This experience enhances my ability to design efficient and comprehensive solutions for complex problems.

Value of Code Implementation: The hands-on coding experience has been invaluable. I have gained insight into implementing theoretical concepts, debugging issues, and optimizing code for efficiency. This skill not only strengthens my technical capabilities but also builds my confidence in translating concepts into tangible solutions.

Interdisciplinary Collaboration: The project required collaboration with experts in agriculture and machine learning. This interdisciplinary interaction exposed me to diverse perspectives, enabling me to better understand the practical implications of technological solutions and fostering effective communication skills.

Career Growth Implications: The skills and insights I have gained from this project are instrumental to my career growth in several ways:

1. **Enhanced Skill Set:** The technical skills acquired, spanning from model design to deployment, position me as a well-rounded data scientist capable of handling complex projects across various industries.
2. **Adaptability:** Navigating the challenges and intricacies of this project has honed my adaptability and resourcefulness. These traits are crucial for thriving in dynamic work environments.

3. **Innovation and Problem-Solving:** The project's emphasis on solving real-world problems using innovative solutions has sparked my creativity and deepened my problem-solving abilities. These attributes are fundamental to driving advancements in any field.

4. **Collaborative Aptitude:** Interdisciplinary collaboration has underscored the significance of effective communication and understanding diverse perspectives. This exposure enhances my ability to contribute effectively within multidisciplinary teams.

5. **Confidence in Implementation:** Having translated theoretical knowledge into practical code implementations, I am more confident in approaching projects from conception to deployment, a critical skill for career progression.

In conclusion, my engagement in the crop and weed detection project has been transformative. It has empowered me with technical expertise, practical problem-solving capabilities, and a holistic understanding of how technological solutions intersect with real-world challenges. I am optimistic that the skills and insights gained will serve as a solid foundation for my continuous growth in the field of data science and machine learning.

7 Future work scope

While the crop and weed detection project has laid a strong foundation, there are several simple yet impactful areas for future exploration and improvement:

1. Increasing Training Duration: Training a neural network involves iteratively updating its parameters based on the dataset. The number of iterations, known as epochs, plays a significant role in how well the model learns. Increasing the training duration involves running more epochs, allowing the model to see the data multiple times and potentially converge to a better solution. However, there's a balance to strike – too few epochs may result in underfitting, while too many could lead to overfitting. By gradually increasing the training duration and monitoring validation performance, you can determine the optimal number of epochs that yields the best accuracy without overfitting.

2. End-to-End Deployment: End-to-end deployment involves taking the trained model and making it accessible for real-world usage. This encompasses deploying the model on a cloud platform, such as AWS or Azure, or deploying it on edge devices like Raspberry Pi or specialized hardware. This is important because a trained model is valuable only when it can be used to make predictions on new, unseen data. Deploying the model involves converting it into a format that can be loaded on the chosen platform, setting up API endpoints or interfaces for data input, and ensuring the necessary libraries and dependencies are available. This step showcases the entire pipeline, from training the model to using it for real-time predictions.

3. User Interface: Creating a user interface involves building a simple graphical interface that allows users to interact with your trained model without needing to write code. In the context of the crop and weed detection project, the user interface could be a web application or a mobile app. Users would be able to upload images from their devices, and the app would pass these images to the model for predictions. The model's output – which could include class labels (crop or weed) and bounding box coordinates – would be displayed back to the user. This makes the solution more user-friendly and accessible to individuals who might not be familiar with coding or machine learning concepts. The user interface adds a layer of usability and convenience to the project, expanding its potential user base.

8 Reference:

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