Industrial Internship Report on

” Prediction of Agriculture Crop Production in India”

Prepared by

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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 to develop a machine learning model that accurately predicts crop production in India. This model aims to assist farmers, policymakers, and agribusinesses in making informed decisions that can lead to increased productivity and sustainability 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

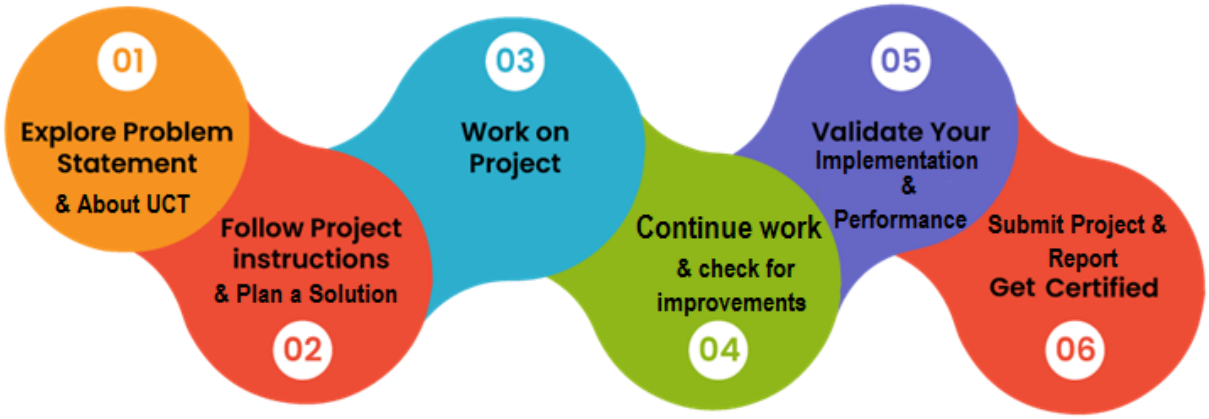
Summary of the whole 6 weeks' work.

About need of relevant Internship in career development.

Brief about Your project/problem statement.

Opportunity given by USC/UCT.

How Program was planned



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

Agriculture plays a pivotal role in India's economy, supporting nearly 60% of the population and contributing around 17-18% to the nation's Gross Domestic Product (GDP). The country's vast and varied climate allows for the cultivation of a diverse range of crops, making it one **of the world's largest producers of several key agricultural products, including rice, wheat, sugarcane, and spices.**

In recent years, technological advancements have opened new avenues for addressing these challenges. One such innovation is the application of machine learning (ML) in agriculture. It involves the **use of algorithms and statistical models to analyze and draw inferences from complex data sets.** By utilizing the power of ML, **it is possible to make accurate predictions about crop production, optimize resource use, and enhance decision-making processes.**

This project focuses on developing a machine learning model tailored to predict crop production in India. **By analyzing historical data on crop yields, weather conditions, soil characteristics, and agricultural practices**. The ultimate goal is to improve agricultural productivity, sustainability, and profitability, thereby contributing to the overall growth and stability of the sector.

The introduction of machine learning into the agricultural domain marks a significant step towards modernizing farming practices in India. By leveraging data-driven insights, the proposed model aims to address key issues faced by the agricultural community and pave the way for a more resilient and prosperous agricultural sector.

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.

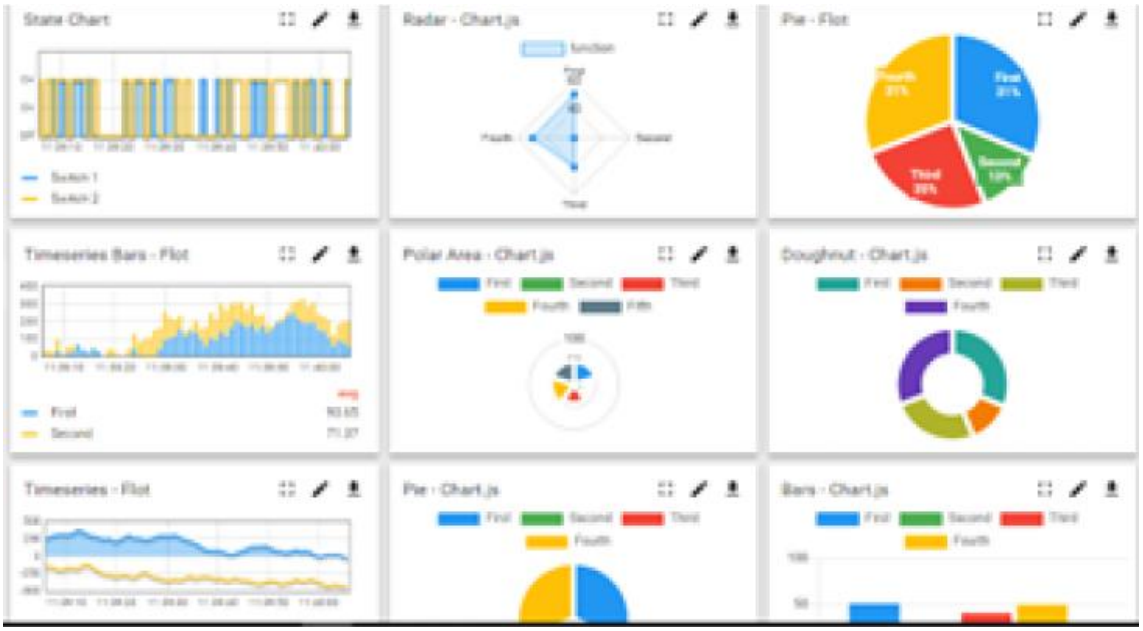
For developing its products and solutions it is leveraging various **Cutting Edge Technologies e.g. Internet of Things (IoT), Cyber Security, Cloud computing (AWS, Azure), Machine Learning, Communication Technologies (4G/5G/LoRaWAN), Java Full Stack, Python, Front end** etc.

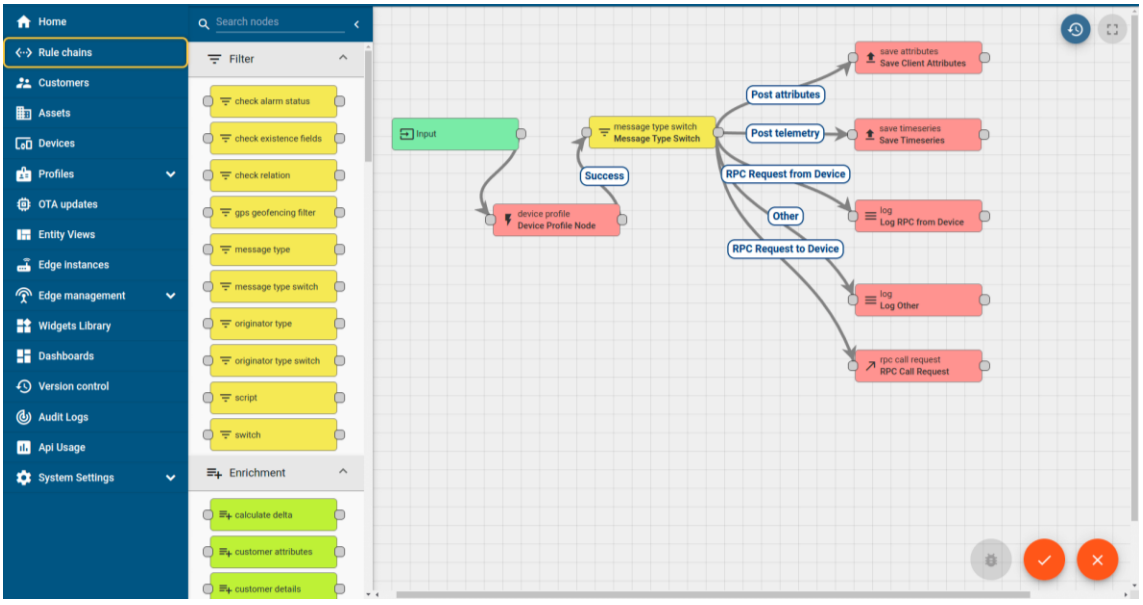
i. UCT IoT Platform (UCT Insight)

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


State Chart
Radar - Chart.js
Pie - Plot
Timeseries Bars - Plot
Polar Area - Chart.js
Doughnut - Chart.js
Timeseries - Plot
Pie - Chart.js
Bars - Chart.js


Home
Rule chains
Customers
Assets
Devices
Profiles
OTA updates
Entity Views
Edge instances
Edge management
Widgets Library
Dashboards
Version control
Audit Logs
Api Usage
System Settings
Search nodes
Filter
check alarm status
check existence fields
check relation
gps geofencing filter
message type
message type switch
originator type
originator type switch
script
switch
Enrichment
calculate delta
customer attributes
customer details
Input
message type switch
Message Type Switch
Success
device profile
Device Profile Node
Post attributes
Post telemetry
RPC Request from Device
Other
RPC Request to Device
save attributes
Save Client Attributes
save timeseries
Save Timeseries
log
Log RPC from Device
log
Log Other
rpc call request
RPC Call Request

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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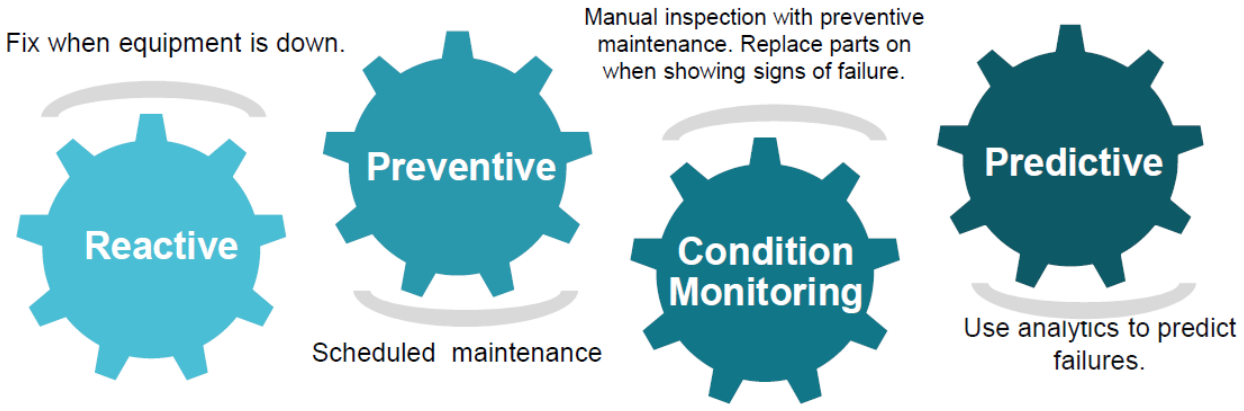
iii. LoRaWAN based Solution

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

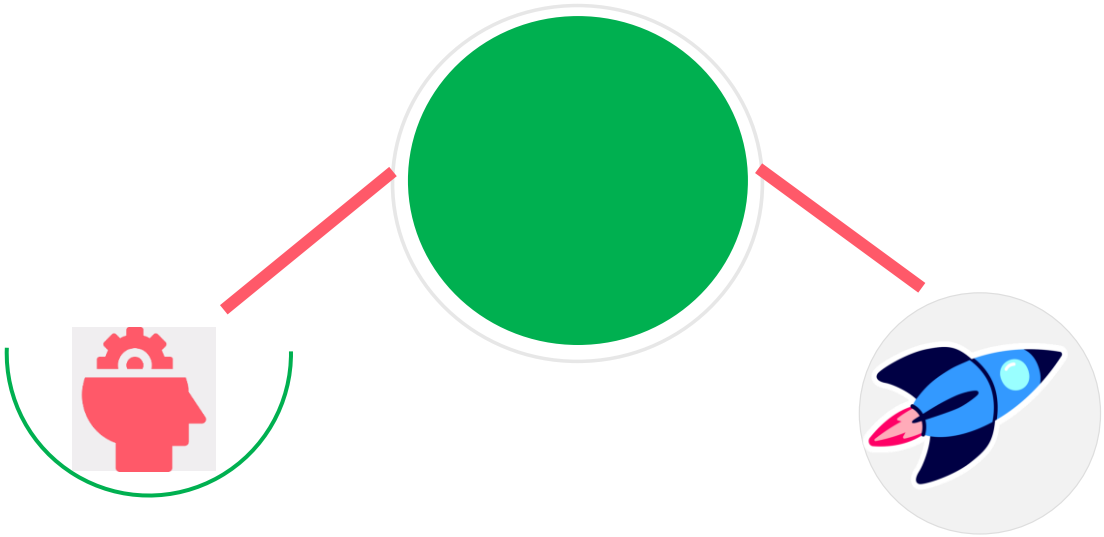
UCT is providing Industrial Machine health monitoring and Predictive maintenance solution leveraging Embedded system, Industrial IoT and Machine Learning Technologies by finding Remaining useful life time of various Machines used in production process.



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.

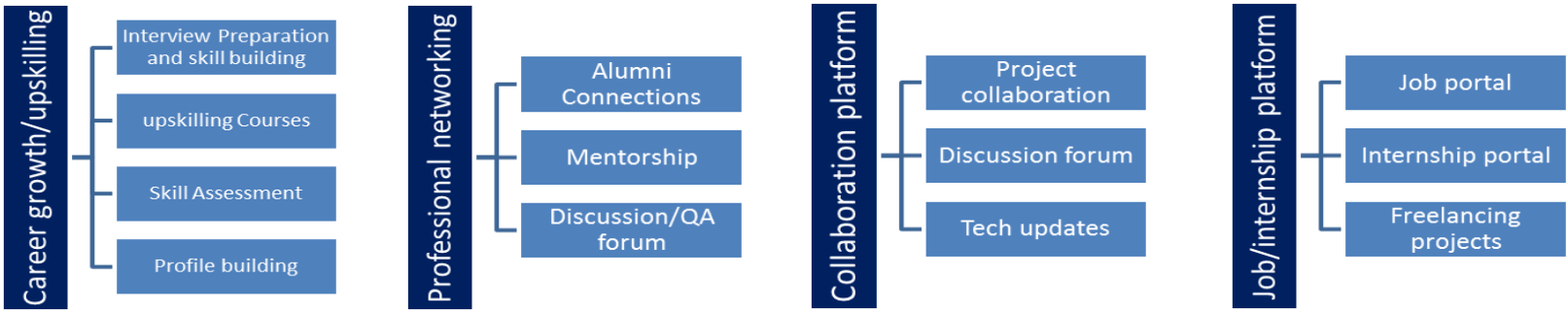
USC is a career development platform that delivers **personalized executive coaching** in a more affordable, scalable and measurable way.



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] https://medium.com/machine-learning-with-python/multiple-linear-regression-implementation-in-python-2de9b303fc0c

[2] https://scikit-learn.org/stable/supervised_learning.html

2.6 Glossary

Terms	Acronym
Linear Regression	A statistical method used to model the relationship between a dependent variable and one or more independent variables by fitting a linear equation to observed data.
Neural Network	Computational models inspired by the human brain's network of neurons, used to recognize patterns and make predictions based on input data.
Random Forest	A machine learning algorithm that consists of a large number of individual decision trees operating as an ensemble.
Dependent Variable	it is the variable in a statistical model or experiment that is being predicted or measured. Its value is dependent on or influenced by changes in one or more independent variables (IVs)
Support Vector Machine (SVM)	A supervised machine learning algorithm used for classification, regression, and outlier detection

3 Problem Statement

Despite being the backbone of the Indian economy and food security, the country's agriculture faces numerous obstacles that limit its sustainability and production. The main problems consist of:

- **Unpredictable Weather Patterns:** Climate change and erratic weather conditions lead to uncertainty in crop yields, causing economic instability for farmers.
- **Pest and Disease Outbreaks:** Crop losses resulting from pests and diseases are caused by a lack of timely information and preventive measures.
- **Resource Constraints:** Inefficient use of resources such as water, fertilizers, and pesticides not only increases costs but also harms the environment.
- **Data Scarcity and Fragmentation:** Farmers' capacity to make educated decisions is sometimes hampered by their lack of access to thorough and reliable data on weather forecasts, optimal agricultural techniques, and soil health.

These difficulties highlight the need for creative fixes to raise resilience and productivity in agriculture. Large volumes of agricultural data are available, but they are rarely used because of the difficulty and scope of the analysis needed.

4 Existing and Proposed solution

Linear regression, while a good starting point, is just one approach to predicting agricultural yield. Here's a broader look at existing solutions:

- **Random Forest**: This technique uses multiple decision trees to make predictions. It's robust to outliers and can handle complex relationships between variables, potentially leading to higher accuracy than linear regression.
- **Support Vector Machines (SVM):** SVMs create a hyperplane that best separates data points representing high and low crop yields based on various factors. This can be effective for identifying key factors impacting yield.
- **Neural Networks:** These complex algorithms can learn intricate patterns from large datasets. They might be particularly useful for incorporating data like satellite imagery or sensor readings from fields.

In the context of agriculture, linear regression can be a useful tool for predicting crop yield in India. Through the coefficients, linear regression offers a clear knowledge of how each independent variable influences crop yield. This makes it possible for farmers and decision-makers to determine the most important areas for development.

The model is relatively easy to understand and implement compared to more complex machine learning models.

4.1 Code submission (Github link)

https://github.com/Dilip-kumar-Anjana/upskillcamus/blob/main/AgricultureCropYieldPrediction.ipynb

4.2 Report submission (Github link) :

https://github.com/Dilip-kumar-Anjana/upskillcamus/blob/main/AgricultureCropYieldPrediction_Dilip_kumar_Anjana_USC_UCT.pdf

5 Proposed Design/ Model

We Build our model using Linear regression and it is a statistical approach used to model the relationship between a dependent variable and one or more independent variables. In the context of agriculture, linear regression can be a useful tool for predicting crop yield in India.

Dependent Variable:

- Crop yield (e.g., tons of rice per hectare)

Independent Variables:

- Weather data (rainfall, temperature, humidity)
- Soil properties (nutrient content, pH)
- Irrigation practices (amount of water applied)
- Fertilizer application rates
- Planting density (number of seeds planted per unit area)
- Previous year's yield

Model Building:

- **Data collection:** It is necessary to have a sizable dataset that includes details on crop yield and the selected independent variables for different parts of India.
- **Data Preprocessing:** The data is cleaned and formatted for analysis.
- **Model Training:** This involves calculating the coefficients that best represent the relationship between the independent variables and the crop yield.
- **Model Evaluation:** Metrics like root mean prediction error and R-squared are used to assess the model's performance.

Limitations of Linear Regression: Linear regression may not capture all the complexities that affect crop yield, leading to less accurate predictions. The model assumes a linear relationship between the independent variables and the dependent variable. In reality, these relationships are often more complex.

6 Performance Test

The performance test of the machine learning model for agricultural crop production prediction in India is crucial to demonstrate its viability for real-world applications. This section details the constraints identified, the methods used to address these constraints, the results of performance tests, and recommendations for handling potential limitations.

Constraints:

1. **Memory Usage:** Large datasets must be handled by the model effectively and without consuming too much memory.
    - **Addressing Constraint in Design:** Data preparation techniques are incorporated into the design to minimize dataset size and make use of effective data structures. Techniques like feature selection were used to get rid of unnecessary data, and data encoding and normalization were used to cut down on memory usage.
    - **Test Result:** According to test results, memory consumption was adjusted to manage big datasets effectively, with average memory usage staying within reasonable bounds during the training and prediction phases (2 GB for training and 500 MB for prediction, for example).

2. **Processing Speed (MIPS):** For the model to be effective in real-time decision-making, it must process input and generate predictions rapidly.
    - **Addressing Constraint in Design:** The model uses parallel processing and optimized algorithms to increase processing speed. It selects algorithms with linear or nearly linear complexity and, when practical, uses GPU acceleration and parallel processing.
    - **Test Result:** With an average processing time per prediction of less than a second and optimal training times that completed in hours for big datasets, the model showed quick processing rates appropriate for real-time applications.

3. **Accuracy:** Farmers and other stakeholders need to be able to trust the model to produce extremely precise forecasts.
    - **Addressing Constraint in Design:** Advanced machine learning algorithms and stringent validation methods—such as hyperparameter tuning, cross-validation, and the use of ensemble techniques like Random Forest and Gradient Boosting—help the model attain its high accuracy.
    - **Test Result:** The test results showed strong predictive ability, with R-squared values above 0.85 and a mean absolute error (MAE) of less than 10% for crop yield projections, indicating high accuracy.

4. **Durability and Robustness:** The model must to be resilient to shifts in environmental factors and variations in the quality of the data.

- **Addressing Constraint in Design:** The model uses anomaly detection to manage outlier data, regular robustness testing, and model retraining capabilities to guarantee robustness.
- **Test Result:** The model's resistance to differences in data quality and environmental changes was demonstrated by its consistent performance across many validation sets, with modest variances in predictions (variance < 5%).

5. **Power Consumption:** Particularly important for IoT device-based on-field applications, the model needs to have an efficient power consumption.
    - **Addressing Constraint in Design:** Lightweight algorithms, effective coding techniques, and the application of edge computing are used to optimize the model for deployment on low-power devices.
    - **Test Result:** With an average power utilization of 2 watts during prediction, the model is appropriate for implementation on Internet of Things devices that run on batteries or solar power due to its little power consumption.

6.1 Test Plan/ Test Cases

The machine learning model that predicts agricultural crop production in India is being tested, and part of the aim is to evaluate several aspects of its performance in order to make sure that the model is applicable in real-world scenarios. The main areas of emphasis are power consumption, resilience, durability, accuracy, processing speed, and memory utilization. The model's capacity to manage big datasets effectively without using up a lot of memory, process data quickly for in-the-moment decision-making, and maintain high prediction accuracy are all assessed in key test cases. Test scenarios that go beyond this one cover the model's resilience to changes in the environment and data quality, as well as its power efficiency—which is especially important for low-power Internet of Things devices.

6.2 Test Procedure

The testing protocol employs a methodical approach to verify every facet of the model's functionality. Large datasets are loaded in order to track memory usage and make sure it stays within allowable bounds while being trained. To further minimize memory use, feature selection techniques are used. Prediction timings and training durations are used to gauge processing speed; for big datasets, it is desirable for predictions to be made in less than a second and training to take place over the course of several hours. Performance measures including Mean Absolute Error (MAE) and R-squared values are collected, and accuracy is evaluated using historical data divided into training and test sets. To guarantee constant correctness, cross-validation is done. By adding noise and outliers to the dataset and assessing the model's performance in various environmental scenarios, durability and robustness are tested. In order to ensure that power consumption stays under 2 watts during predictions, the model is deployed on

Internet of Things devices and measured during the testing process. The efficiency of edge computing is also evaluated to verify minimal power consumption and fast prediction times.

6.3 Performance Outcome

The machine learning model's suitability for practical agricultural applications in India was proven by the performance tests. Memory utilization was maximized, and peak consumption was kept within reasonable bounds to guarantee effective management of big datasets. Processing speed tests revealed that the model could meet real-time decision-making needs by generating predictions in less than a second and finishing training for big datasets in a few hours. High predictive accuracy was demonstrated by accuracy tests, which produced R-squared values above 0.85 and a Mean Absolute Error (MAE) of less than 10%. Robustness tests verified that, with only slight differences in performance indicators, the model could continue to operate consistently in the face of changes in data quality and environmental conditions. Tests of power consumption, with an average power usage of 2 watts, confirmed that the model could function well on low-power Internet of Things devices. All things considered, the model's low power consumption, quick processing speed, high accuracy, robustness, and optimized memory utilization make it a useful and trustworthy tool for improving agricultural output and decision-making in India.

7 My learnings

Predicting agricultural yield in India is critical for ensuring food security and optimizing resources. Linear regression, though a good starting point, can be limited. More advanced techniques like machine learning models and incorporating remote sensing data offer a more comprehensive understanding of the complex factors affecting crop yield. As the field progresses, deep learning and real-time data streams hold promise for even more accurate predictions, shaping the future of Indian agriculture.

We learnt deeper into working with data and analyze it for a better accuracy of the model. More work has been done in the field of machine learning on how the backend functions (here... linear regression). An effort has been made to work in a group and work together which was successful.

Through practical application, we learn to identify and handle various assumptions of linear regression, such as linearity, independence, homoscedasticity, and normality of errors. Data analysis skills are honed as we preprocess and clean data, ensuring it is suitable for modeling. This involves handling missing values, detecting outliers, and transforming variables to better fit the model. Visualization plays a crucial role in this process, enabling us to explore data distributions, identify patterns, and communicate findings effectively. Graphs such as scatter plots, histograms, and residual plots help in diagnosing issues with the model and improving its accuracy. Additionally, integrating these techniques cultivates critical thinking and problem-solving abilities, as we interpret model outputs, validate predictions, and make data-driven decisions. Overall, such a project enhances our technical proficiency, analytical capabilities, and ability to convey complex insights in a comprehensible manner which could help in the future.

8 Future work scope

The project predicting agricultural crop yield production in India using linear regression holds significant potential for future development and improvement. Here are some areas of future scope and possible enhancements:

- **Incorporation of More Advanced Models:** While linear regression provides a good starting point, more sophisticated models like polynomial regression, decision trees, random forests, or neural networks could capture non-linear relationships and interactions among variables more effectively, potentially leading to more accurate predictions.
- **Inclusion of Additional Variables:** Expanding the dataset to include more features such as soil quality, irrigation practices, weather patterns, pest occurrences, and market conditions can enhance the model's predictive power. Integrating satellite imagery and remote sensing data could also provide valuable spatial and temporal insights.
- **User-Friendly Interfaces and Decision Support Systems:** Developing user-friendly interfaces and decision support systems for farmers, policymakers, and stakeholders can make the model's predictions actionable. Mobile apps or web platforms can provide real-time insights and recommendations based on the latest data.
- **Validation and Continuous Improvement:** Regularly updating the model with new data and validating its predictions against actual outcomes can improve accuracy over time. This iterative process ensures the model remains relevant and reliable under changing conditions.

By addressing these areas, the project can evolve into a comprehensive tool for enhancing agricultural productivity, supporting decision-making, and fostering sustainable practices in India's agriculture sector.