Agriculture prediction using predictive analysis

An Engineering Project in Community Service

Final Report

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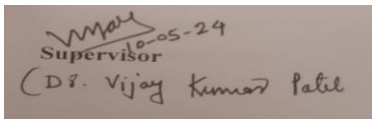
This project report (Final Phase) is submitted for the Project Viva-Voce examination held from 06-05-24 to 10-05-24



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Declaration of Originality

We, hereby declare that this report entitled “Agriculture prediction using predictive analysis” represents our original work carried out for the EPICS project as students of VIT Bhopal University and, to the best of our knowledge, it contains no material previously published or written by another person, nor any material presented for the award of any other degree or diploma of VIT Bhopal University or any other institution. Works of other authors cited in this report have been duly acknowledged under the section "References".

Date: 10.05.2024

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Abstract

Crop prediction through predictive analysis is an indispensable tool in modern agriculture, facilitating informed decision-making and enhancing productivity. Leveraging advanced data analytics techniques, this paper explores the methodology and significance of crop prediction in optimizing agricultural practices. Through the integration of historical data, weather patterns, soil characteristics, and other pertinent factors, predictive models offer insights into future crop yields, aiding farmers in resource allocation, risk mitigation, and market planning. This study delves into the application of various predictive analysis techniques such as machine learning algorithms, remote sensing, and statistical modeling, highlighting their efficacy in forecasting crop outcomes. By harnessing the power of predictive analysis, stakeholders in the agricultural sector can foster sustainability, resilience, and profitability in crop production.

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1. Introduction

Agricultural productivity and food security are critical concerns in the face of a growing global population and changing climatic conditions. In recent years, the intersection of agriculture and technology has offered new avenues for addressing these challenges. One such avenue is the application of machine learning techniques in crop prediction, as explored in the paper *"Crop Prediction using Machine Learning Approaches" by M. Kalimuthu (2020)*[1].

At the forefront of this transformation lies predictive analysis, a multidisciplinary approach that harnesses the power of data to forecast future outcomes. In the realm of agriculture, predictive analysis has emerged as a game-changer, offering farmers, agronomists, policymakers, and other stakeholders unprecedented insights into crop behavior, yield projections, and optimal management strategies. By amalgamating diverse datasets encompassing historical records, meteorological observations, soil characteristics, satellite imagery, and socioeconomic factors, predictive models can unravel complex patterns and relationships, empowering decision-makers to make informed choices with confidence. The significance of crop prediction through predictive analysis extends far beyond the confines of individual farms or regions. It underpins global food security efforts, facilitates sustainable agricultural practices, and drives innovation across the entire food system. Predictive analysis offers a roadmap toward resilience, enabling stakeholders to preemptively mitigate risks, optimize resource allocation, and capitalize on emerging opportunities.

This paper endeavors to delve deep into the realm of crop prediction using predictive analysis, elucidating its methodologies, applications, and implications for agricultural sustainability and productivity. Through a comprehensive exploration of predictive modeling techniques, case studies, and real-world applications, it seeks to showcase the transformative potential of predictive analysis in shaping the future of agriculture. From precision farming and smart irrigation to supply chain optimization and market forecasting, the integration of predictive analytics promises to revolutionize the agricultural landscape, ushering in a new era of efficiency, resilience, and prosper

2. Motivation

The motivation for this study is rooted in the urgent need to address the multifaceted challenges confronting modern agriculture. With the specter of climate change looming large and global population projections on the rise, the imperative to enhance agricultural sustainability, resilience, and productivity has never been more pressing. These challenges necessitate innovative solutions that can provide farmers and stakeholders with actionable insights to navigate uncertainties and optimize resource allocation effectively.

In this context, recent advancements in predictive analytics have emerged as a beacon of hope, offering unprecedented opportunities to revolutionize crop prediction and management practices. Studies such as *"Analysis of agricultural crop yield prediction using statistical techniques of machine learning" (Pant,.. 2021)[7]* serve as inspirations, showcasing the potential of sophisticated statistical techniques and machine learning algorithms to forecast agricultural outcomes with remarkable precision.

Our research endeavors to build upon the foundation laid by such groundbreaking studies, aiming to extend and refine existing methodologies while exploring novel approaches to crop prediction. By leveraging advanced statistical techniques, machine learning algorithms, and interdisciplinary insights, we seek to develop predictive models that can provide more accurate and reliable forecasts of crop yields.

Furthermore, our study is driven by a broader vision of contributing to the advancement of agricultural sustainability and resilience. By improving our understanding of crop behavior and enhancing the predictability of agricultural outcomes, we aim to foster a more sustainable and prosperous future for agriculture.

In summary, our research is motivated by the imperative to address the challenges facing modern agriculture through innovation and collaboration. Drawing inspiration from recent advancements in predictive analytics, we aspire to develop practical solutions that can empower farmers and stakeholders, drive productivity gains, and promote the long-term sustainability of agriculture. Through our endeavors, we seek to realize the transformative potential of predictive analytics in shaping the future of agriculture.

3. Objective

The objectives of our research endeavor are outlined as follows:

1. Hybrid Modeling Approach Development: Our first objective is to develop a hybrid modeling approach that combines the strengths of machine learning techniques and statistical models, as exemplified by the studies of *"Crop Yield Forecast at Different Growth Stage of Wheat Crop using Statistical Model under Semi Arid Region" by Ananta Vashisth(2014)*[11] respectively. This involves integrating advanced machine learning algorithms with traditional statistical methods to capture both the complex nonlinear relationships inherent in crop growth dynamics and the underlying statistical patterns characteristic of agricultural systems. By leveraging the complementary strengths of these approaches, we aim to enhance the accuracy and robustness of our crop yield prediction framework.

2. Growth Stage-Specific Forecasting: Recognizing the importance of accounting for the varying growth stages and phenological processes of crops, our second objective is to develop growth stage-specific forecasting models. Drawing inspiration from the work of *Ananta Vashisth*. (2014), we aim to tailor our predictive models to capture the distinct environmental and physiological factors influencing crop development at different stages of growth. By incorporating stage-specific variables and adapting model parameters accordingly, we seek to improve the precision and reliability of crop yield forecasts throughout the growing season.

3. Model Validation and Evaluation: Our study endeavors to rigorously validate and evaluate the performance of the developed crop yield prediction framework. This involves conducting comprehensive validation exercises using independent datasets, field observations, and ground-truth data collected from experimental plots or farm-level surveys.

Decision Support Tool Integration: Finally, our research aims to integrate the validated crop yield prediction models into a user-friendly decision support tool for agricultural stakeholders. This tool will provide actionable insights and recommendations to farmers, agronomists, and policymakers, facilitating informed decision-making related to crop management, resource allocation, and risk mitigation strategies. By leveraging cutting-edge modeling techniques and user-friendly interfaces, we aspire to democratize access to advanced crop yield forecasting technology and empower stakeholders to optimize agricultural productivity and resilience.

4. Existing Work/ Literature Review

Soil Spectroscopy and Agriculture

Soil spectroscopy has emerged as a critical tool in modern agricultural practices due to its efficiency and accuracy in analyzing soil properties. Traditional chemical methods for soil analysis have limitations in terms of time, cost, and environmental impact. Spectroscopy, particularly in the infrared range, has gained prominence as a rapid, cost-effective, and ecofriendly technique for assessing soil properties. This method enables the generation of hyperspectral data, offering detailed insights into various soil characteristics (*A Case Study of Lentil*) [8].

Machine Learning in Soil Property Prediction

The integration of machine learning (ML) techniques with spectroscopic data has revolutionized soil property prediction. Studies have indicated the superiority of ML approaches over conventional methods in accurately predicting soil attributes (*A Case Study of Lentil*) [8]. *Crop Yield Prediction Using Time Series Models (2014)* [9] observed a transition in ML models, favoring advanced algorithms like Random Forest (RF) over Support Vector Machines (SVM) and other simpler techniques. The ability of ML models, such as Multivariate Regression, Random Forest Regression, Support Vector Machine, and Gradient Boosting, to predict soil properties with varying degrees of accuracy has been widely explored.

Challenges in Agricultural Practices and Technology Integration

The adoption of modern agricultural techniques, including high-yielding seeds, mechanized tools, and chemical fertilizers, transformed Indian agriculture during the green revolution. However, the excessive reliance on chemical fertilizers has led to concerns regarding soil fertility and productivity. Soil health degradation due to inadequate fertilization matching soil requirements has become a significant issue, necessitating accurate soil property assessments.

Advancements and Application of Machine Learning Models

Literature highlights the potential of machine learning models trained on spectroscopic data to accurately predict soil properties, aiding farmers in making informed decisions regarding fertilizer selection (*A Case Study of Lentil*, 2018) [8]. Researchers have employed various ML algorithms and comparative analyses to identify the most effective models for soil property prediction.

Challenges in Crop Yield Prediction:

Crop yield prediction plays a pivotal role in global food security strategies and agricultural advancements. However, the complexity inherent in predicting crop yields arises from

various factors. For instance, genotype information for each plant involves highdimensional marker data, encompassing numerous markers that represent the genotype. These genetic markers interact with diverse environmental elements and agricultural practices, making accurate yield prediction challenging.

Evolution of Prediction Models

Traditionally, crop yield prediction relied on conventional statistical approaches. However, recent advancements have introduced machine learning (ML) methods to enhance accuracy and efficiency in yield prediction. ML techniques such as multivariate regression, decision trees, association rule mining, and artificial neural networks have gained prominence in predicting crop yields, offering improved predictive capabilities compared to traditional models.

Existing Crop Yield Prediction Models

Numerous researchers have contributed to the development and implementation of crop yield prediction models. Their studies have explored diverse methodologies and techniques to forecast crop yields. These models have been built upon various datasets and encompass a range of predictive algorithms, contributing valuable insights into the complex dynamics of crop yield prediction.

5. Topic of Work

5.1. Dataset Description

We collected the rainfall data from 1901 to 2020 and the crop yield data of paddy, maize, ragi, sugarcane, and cotton from the Indian government website [19]. Additionally, the metrological data from the Indian metrological department website was incorporated [20]. From 1901 to 2000 as the training data manually collected the total crop yield yearly production from the local agricultural departments and from 2001 to 2020 as the testing data from the Andhra Pradesh government websites and the Indian government agricultural websites [21]. The crop yield dataset consists of 25,515 rows and the number of features in the dataset is 26. The features used in this research. The maximum temperature varies from 30.1 °C to 45.4 °C, the minimum temperature varies from 19 °C to 32.5 °C, the wind speed varies from 12 km/h to 21 km/h, and the relative humidity varies from 52 to 79, and the solar radiation varies from 8.1 to 10.9. The rainfall varies from 0.2 mm to 7 mthe major crops that were cultivated in India and their yields in the year 2000. Rice is one of the major crops cultivated in India. State-based statistics were collected from the agricultural departments and from the Indian government agricultural websites [21]. The yielded data were reported in units of kg per hectare.

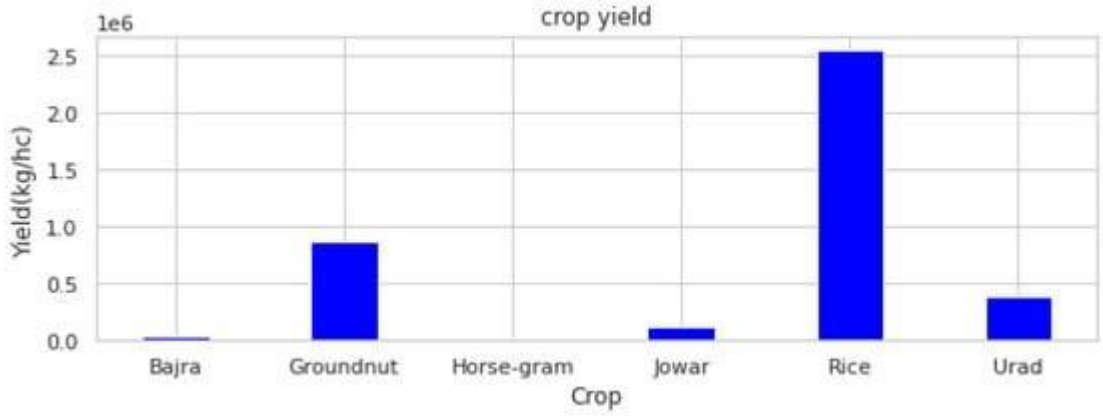

Figure 1. Crop yield data.

5.2. Predictive Modeling

Based on the differences in rainfall, we used predictive modeling to forecast the Kharif crop yield for the year 2021. The feature selection was performed on the attributes by combining the rainfall data with the crop yield data. As the Kharif crop mainly depends on the information on rainfall, this study only used data from June to September as the training data to do model training. Therefore, weather data is helping to provide input to train the model and crop yield data as predicted outcomes.

5.3. Padding and Optimization

The imported data may consist of unfilled data. To complement the incomplete measures, the ”−1” padding technique was used. Optimizers minimize the error by updating the weight parameters and reducing the training time. An optimizer is an algorithm or a function that changes the attributes of the deep learning models such as learning rate and weights to reduce the error [22]. Gradient descent is a first-order optimization algorithm, and it is dependent on the first-order derivate of the error function of the deep learning model. Optimizers find a way to alter the weights to minimize the error.

5.4. Existing Models

5.4.1. Convolution Neural Network (CNN)

CNN comprises three layers; namely, convolution, pooling, and fully connected ones, and this model automatically detects distinctly. The term convolution represents the mathematical function of convolution, i.e., a linear operation where two functions are multiplied to get the third function. The pooling layer reduces computational costs by reducing the size of the convolved feature map. The fully connected layer predicts the class based on extracted features and the convolution process output.

5.4.2. Recurrent Neural Network (RNN)

RNN saves the output of a specific layer and feeds it back to the input of another to predict the result of the layer. It can memorize the previous inputs due to its internal memory. RNN has a vanishing gradient and exploding gradient issues.

5.4.3. Gated Recurrent Unit (GRU)

GRU uses gates to control the flow of information. It maintains two gates called reset and update where the reset gate contains the information to remember, and the update gate determines future data based on past information.

5.5. Project Code

```
import numpy as np import pandas as pd import matplotlib.pyplot as plt import seaborn as sns
crop_data=pd.read_csv("Crop_recommendation.csv") crop_data
from sklearn.model_selection import train_test_split x_train,x_test,y_train,y_test = train_test_split(x,y,test_size=0.25, random_state= 0) from sklearn.preprocessing import StandardScaler scaler = StandardScaler() x_train = scaler.fit_transform(x_train) x_test = scaler.transform(x_test)
from sklearn.tree import DecisionTreeClassifier clf = DecisionTreeClassifier(random_state=6)
decision_tree_model = MultiOutputClassifier(clf, n_jobs=-1)
decision_tree_model.fit(x_train, y_train)
cm=confusion_matrix(y_test.values.argmax(axis=1), decision_pred.argmax(axis=1))
ax= plt.subplot()
sns.heatmap(cm, annot=True, fmt='g', ax=ax);
ax.set_xlabel('Predicted labels');ax.set_ylabel('True labels');
ax.set_title('Confusion Matrix'); forest = RandomForestClassifier(random_state=1) forest_model = MultiOutputClassifier(forest, n_jobs=-1)
forest_model.fit(x_train, y_train) from sklearn.neighbors import KNeighborsClassifier

knn_clf=KNeighborsClassifier()
knn_model = MultiOutputClassifier(knn_clf, n_jobs=-1)
knn_model.fit(x_train, y_train) from sklearn.linear_model import LogisticRegression

lr_clf = LogisticRegression()
lr_model = MultiOutputClassifier(lr_clf, n_jobs=-1)
lr_model.fit(x_train, y_train) lr_pred = lr_model.predict(x_test)
df = pd.DataFrame(list(Accuracies.items()), columns=['Model', 'Accuracy'])
plt.figure(figsize=(11,8))

plt.title("Accuracy Comparision")
plt.xlabel("Algorithm") plt.ylabel("Accuracy")
```

```
sns.barplot(x='Model', y='Accuracy', data=df)
plt.xticks(rotation=45) for index, row in
df.iterrows():
  plt.text(index, row['Accuracy'], round(row['Accuracy'], 4), color='black',
ha="center") plt.show()
Final_model = lr_model input_features =
input_features_1.reshape(1,-1) model_input =
scaler.transform(input_features) Final_prediction =
Final_model.predict(model_input)
labels =
['Apple','Banana','Blackgram','Chickpea','Coconut','Coffee','Cotton','Grapes','Jute','Ki
dneybeans','Lentil','Maize','Mango','Mungbean','Mothbeans','Muskmelon','Orange','Pa
paya','Pigeonpeas','Pomegranate','Rice','Watermelon'] indices =
np.where(Final_prediction == 1)[1] original_labels = [labels[i] for i in indices]
print(original_labels)
```

6. Conclusion

Our research underscores the vital role of integrating machine learning algorithms and IoT sensors in modern agriculture, aiming to enhance crop production efficiency and mitigate waste through informed decision-making. Through experimental analysis, we investigated the impact of altering labels on data analysis algorithms, revealing insights into accuracy, error values, and processing times across various classification models. By harnessing comprehensive data, including real-time insights from IoT sensors, farmers can make more informed decisions regarding factors influencing crop growth. Despite challenges in deploying machine learning in agriculture, our findings exhibit promising outcomes, indicating the increasing importance of machine learning methodologies for predicting production outcomes in agriculture. Notably, our study highlights the criticality of appropriate feature selection for improving algorithmic accuracy in agricultural data analysis, with the highest accuracies achieved when considering temperature, humidity, pH, and precipitation features. These results shed light on the potential benefits of such technologies in modern agriculture, offering avenues for optimizing crop production, minimizing waste, and bolstering global food security. Looking ahead, future research will delve into evaluating a broader spectrum of crop data using GPS-based IoT and sensor data from diverse geographic regions, facilitating a deeper understanding of crop varieties' performance under different conditions and enabling informed decision-making through machine learning algorithms.

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8. Biodata with pictures

21BAI10314 Kaviya Lakshmi

As an AI and ML enthusiast, I have cultivated a solid understanding of key technologies such as C, Python, machine learning, deep learning, IoT, and robotics. Through my involvement in creating Zoho extensions, I've gained hands-on experience with emerging technologies, further bolstering my skills and insights into the tech landscape. My passion lies in leveraging AI and ML to tackle real-world problems, and I am particularly drawn to projects that are guided by user feedback and experience. I am committed to applying my expertise to develop innovative solutions that not only meet but exceed user expectations, pushing the boundaries of what is possible in the realm of artificial intelligence and machine learning. With a foundation built on a diverse range of technical proficiencies and a keen interest in addressing challenges head-on, I am eager to contribute to AI and ML initiatives that drive meaningful impact and progress.

21BEC10018 Karish Adithya

As a driven B. Tech student majoring in Electronics and Communication at VIT Bhopal, I am deeply passionate about harnessing my expertise in teamwork, IoT, and rapid learning to make a meaningful impact within the technology sector. Through engaging in a myriad of projects, including the development of LPG gas detectors and automated water irrigation systems, I have acquired invaluable hands-on experience that has sharpened my problemsolving abilities and technical acumen. These projects have not only fortified my understanding of electronics and communication but also instilled in me a profound sense of purpose in utilizing technology for societal benefit. Moreover, my personal fascination with robotics serves as a driving force, propelling me to explore innovative solutions and push the boundaries of what is achievable within this field. With a steadfast commitment to continuous improvement and a fervent dedication to leveraging technology for positive change, I am eager to contribute my skills and knowledge to drive impactful advancements in the tech industry.

21BCY10155 Eyal Shagithyan

As a student specializing in cybersecurity with a robust background in digital forensics, Python programming, front-end development, and UI/UX design, I bring a diverse skill set primed for innovation. My experience in creating Zoho extensions has provided me with valuable insights into emerging technologies, honing my ability to adapt and thrive in dynamic digital landscapes. Passionate about leveraging technology to address contemporary challenges, I am eager to contribute my expertise towards designing cuttingedge solutions that not only meet but exceed the evolving demands of the technological landscape. My foundation in cybersecurity underscores my commitment to ensuring the integrity and security of the systems I work with, while my proficiency in Python, front-end development, and UI/UX design empowers me to craft user-centric, intuitive experiences that drive technological advancements forward.

21BAI10253 Tejas Balamukesh

As an engineering student deeply passionate about Artificial Intelligence (AI) and Machine Learning (ML), I am committed to continuously refining my expertise through ongoing coursework and hands-on projects. With a solid foundation in Python programming, I am constantly seeking opportunities to expand my knowledge and explore new advancements in AI and ML technologies. My enthusiasm for learning is matched only by my eagerness to collaborate with like-minded individuals to collectively foster growth and innovation. I firmly believe that collaboration is key to success in the rapidly evolving field of AI and ML, and I am excited about the prospect of joining forces with fellow enthusiasts to drive meaningful advancements and tackle complex challenges. Let's collaborate, learn, and grow together to make a positive impact in the world of technology.
21BCE10152 Sushant Aggarwal

A tech enthusiast with a natural inclination for strategic thinking, I possess a keen ability to dissect complex problems and devise innovative solutions. With a robust skill set in problem-solving and a fervent passion for tackling coding challenges head-on, I thrive in dynamic environments where creativity and adaptability are paramount. My dedication to continuous learning and growth drives me to stay at the forefront of technological advancements, constantly expanding my knowledge base and honing my craft. Excited by the prospect of collaboration, I am eager to engage with like-minded individuals to tackle intricate problems and push the boundaries of what is possible in the world of programming. With a relentless drive for excellence and a commitment to pushing past obstacles, I am poised to make significant contributions to the ever-evolving landscape of technology. 21BCY10139 Sri Charan Sal Reddy

As a computer science student, I boast proficiency in a diverse range of technical domains including Python, Windows, Linux, bash commands, and scripting. However, my deepest passion lies in the realms of cybersecurity, computer networks, and operating systems. With a dedicated focus on generating unique ideas and solutions, I am driven by the pursuit of tackling digital challenges head-on. My experience encompasses collaborative endeavors within dynamic environments, where I thrive on the exchange of ideas and the synergy of teamwork. Eager to channel my skills and passions into addressing complex challenges, my ultimate aim is to deliver exceptional user experiences by leveraging innovative approaches and cutting-edge technologies.

21BCE10071 Ajitava Das

As a driven computer science student, my passion for system development, cybersecurity, AI, and machine learning is matched only by my strong foundation in Python, Linux, and data structures. I am deeply committed to crafting seamless and engaging digital solutions that not only meet but exceed user expectations. With experience collaborating in dynamic environments, I thrive on tackling complex challenges and delivering exceptional user experiences. I am eager to contribute my skills and enthusiasm to drive innovation, solve problems, and make a tangible impact in the ever-evolving landscape of technology. 21BCE11634 Harshit Kewat

As a driven and creative Computer Science student, I am fueled by a passion for crafting innovative software solutions that address real-world challenges. Currently pursuing my B.Tech. in Computer Science and Engineering at VIT Bhopal University, I am immersed in a learning environment that fosters growth and exploration. With hands-on experience in

programming languages such as Java and Python, I possess a solid foundation upon which to build my technical expertise. Actively seeking opportunities to stay abreast of new technologies shaping our daily lives, I am committed to continuous learning and development. Eager to leverage my skills and problem-solving abilities, I am enthusiastic about contributing to collaborative team environments where I can make a positive impact and drive meaningful change through technology.

21BCE11060 Jyotisna Tiwari

An enthusiastic and driven computer science student, I am eager to bridge the gap between theoretical knowledge and practical application. With a fervent desire to contribute to innovative projects, I am actively seeking opportunities to immerse myself in diverse technical areas while gaining invaluable hands-on experience. My passion for technology drives me to continuously expand my skill set and tackle real-world challenges with enthusiasm and dedication. Committed to lifelong learning, I approach every opportunity as a chance to grow and make meaningful contributions to the field of computer science. 21BCE10614 Uday Gorai

As a pre-final year student majoring in Computer Science and Engineering at VIT Bhopal University, I am Uday Gorai, driven by an insatiable desire to address contemporary global challenges through innovative technological solutions. The thrill of problem-solving fuels my relentless pursuit of knowledge and exploration of emerging technologies. Currently, my focus lies in delving into the realm of web development, where I am actively engaged in learning and honing my skills. I approach every opportunity with eagerness to absorb new concepts and techniques, recognizing that continuous learning is essential for personal and professional growth. With a keen interest in staying abreast of the latest advancements, I am poised to leverage my enthusiasm and dedication to make meaningful contributions in the ever-evolving field of technology.