iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 13 **Issue:** IV **Month of publication:** April 2025

DOI: https://doi.org/10.22214/ijraset.2025.69116

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 13 Issue IV Apr 2025- Available at www.ijraset.com

Real-Time Seed Scanning and Germination Prediction Using Machine Learning: The GermiScan Project

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Abstract: ***Accurate prediction of seed germination is critical for improving agricultural yield and resource management. This paper explores the use of machine learning to predict seed germination rates in real-time through image analysis. The project, named GermiScan, utilizes a camera-based system to capture seed images and predict germination based on physical features such as size and colour. A machine learning model was trained using labelled data to assess germination potential. The system was tested on multiple seed types, demonstrating promising results in predicting germination rates. Additionally, GermiScan's real-time scanning approach offers potential for large-scale agricultural applications, providing farmers with actionable insights to optimize planting strategies. The study also discusses challenges in model accuracy and suggests future work to enhance prediction capabilities by incorporating more seed varieties and refining the machine learning algorithm.***
Keywords: Seed Germination, Machine Learning, Real-Time Scanning, Agriculture, Prediction Models, GermiScan.

I. INTRODUCTION

In recent years, machine learning has become a vital tool in improving agricultural efficiency, particularly in assessing seed quality. Accurate prediction of seed germination is essential for optimizing crop yields and making effective use of resources. The GermiScan project leverages machine learning to predict germination rates in real-time through image analysis, focusing on key seed characteristics such as size and colour. A diverse dataset of seed images was collected to train the machine learning model, which was then tested for its ability to predict germination rates accurately. The results show that the system provides valuable insights to assist farmers in making informed decisions during the planting process. While initial performance is promising, further refinement is needed to increase its effectiveness across a broader range of seeds and real-world conditions. This study highlights the potential of machine learning in agricultural applications, offering a scalable solution for real-time germination prediction. GermiScan's contribution to improving agricultural practices can lead to enhanced crop management and resource optimization, supporting more sustainable farming methods.

II. LITERATURE SURVEY

*1) Raghavendra Srinivasaiah et al. (2020**). Machine Learning Techniques for Seed Germination Prediction.***
In this study, the authors explored the use of machine learning techniques to predict seed germination with high accuracy. The research emphasizes the potential of machine learning models to handle complex data patterns, improving predictive accuracy in controlled environments. However, the dataset diversity was limited, and the models' real-world application across varied seed types remains a challenge. The study suggests the need for standardized datasets to ensure broader applicability in agriculture.

2) Swathi K Hiremath et al. (2020). Deep Learning for Seed Classification.
This paper discusses deep learning techniques for seed classification, specifically using convolutional neural networks (CNNs) to achieve effective classification. Despite the high accuracy in controlled settings, the computational intensity of these methods is a limitation, especially for real-time processing. The authors highlight the lack of real-time capabilities as a significant gap in applying deep learning to large-scale agricultural systems.

3) Sandip Ramdasrao Mokle et al. (2020). Image Processing for Seed Germination Analysis.
Mokle et al. focus on the use of image processing techniques to analyze seed germination, providing strong results in image analysis but with a narrow focus on specific seed types. The study points out the need to explore additional seed varieties and improve the generalizability of the models for diverse agricultural applications.

4) Andreas Kamilaris & Francesc X. Prenafeta-Boldú (2018). Survey of Deep Learning Applications in Agriculture.
This comprehensive survey reviews various deep learning applications in agriculture, offering insights into their potential across different domains, including crop monitoring and seed analysis. However, the conclusions are generalized, lacking specific implementation details for seed germination. The authors recommend further research to focus on the unique challenges of seed germination prediction using deep learning.

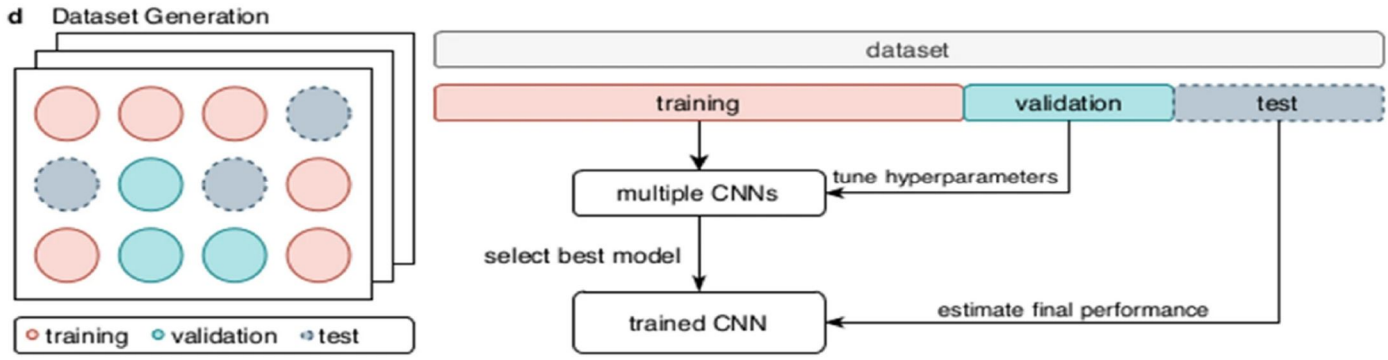
5) Sandeep Musale & Vikram Ghiye (2023). Automated Image Processing for Seed Germination Prediction.
The authors present a novel approach combining image processing and automation for seed germination prediction. While the system shows promise, it faces challenges when implemented in real-world agricultural settings. The study highlights the lack of integration with existing agricultural practices as a key limitation and suggests further work to develop a more robust system for practical use.

III. METHODOLOGY

This methodology combines machine learning and real-time image processing to address the challenge of seed germination prediction. The following steps were undertaken to develop GermiScan, a system designed to predict seed germination rates based on image data:

1) *Data Collection:* Seed images were gathered to capture variations in size, colour, and shape, ensuring diversity in environmental conditions to train a robust model.
2) *Data Pre-processing:* Images were resized and formatted for model input, with data augmentation applied to improve training diversity and model adaptability.
3) *Model Selection:* A pre-trained CNN model was chosen for transfer learning, fine-tuned specifically to predict seed germination based on visual traits.
4) *Training Process:* The model was trained on the seed dataset, with 80% used for training and 20% for testing, optimizing its accuracy through iterative learning.
5) *Evaluation:* Model performance was measured using accuracy and real-world tests, with emphasis on practical effectiveness in varied conditions.
6) *System Development:* A real-time scanning tool was developed using Python and machine learning libraries to process seed images and predict germination rates.
7) *Practical Application:* The GermiScan system provides real-time germination predictions through a user-friendly dashboard, aiding agricultural decision-making.
8) *Continuous Improvement:* Ongoing efforts aim to refine the model's accuracy by expanding the dataset and enhancing its ability to handle diverse seed types.

IV. SYSTEM ARCHITECTURE



V. CONCLUSION

In conclusion, this study emphasizes the significance of seed germination prediction using machine learning techniques, particularly with real-time image analysis. While the initial model achieved basic functionality, the need for further improvements was evident. By implementing and refining this approach, we aim to enhance the accuracy of seed germination predictions and contribute towards more efficient agricultural practices through a user-friendly system.

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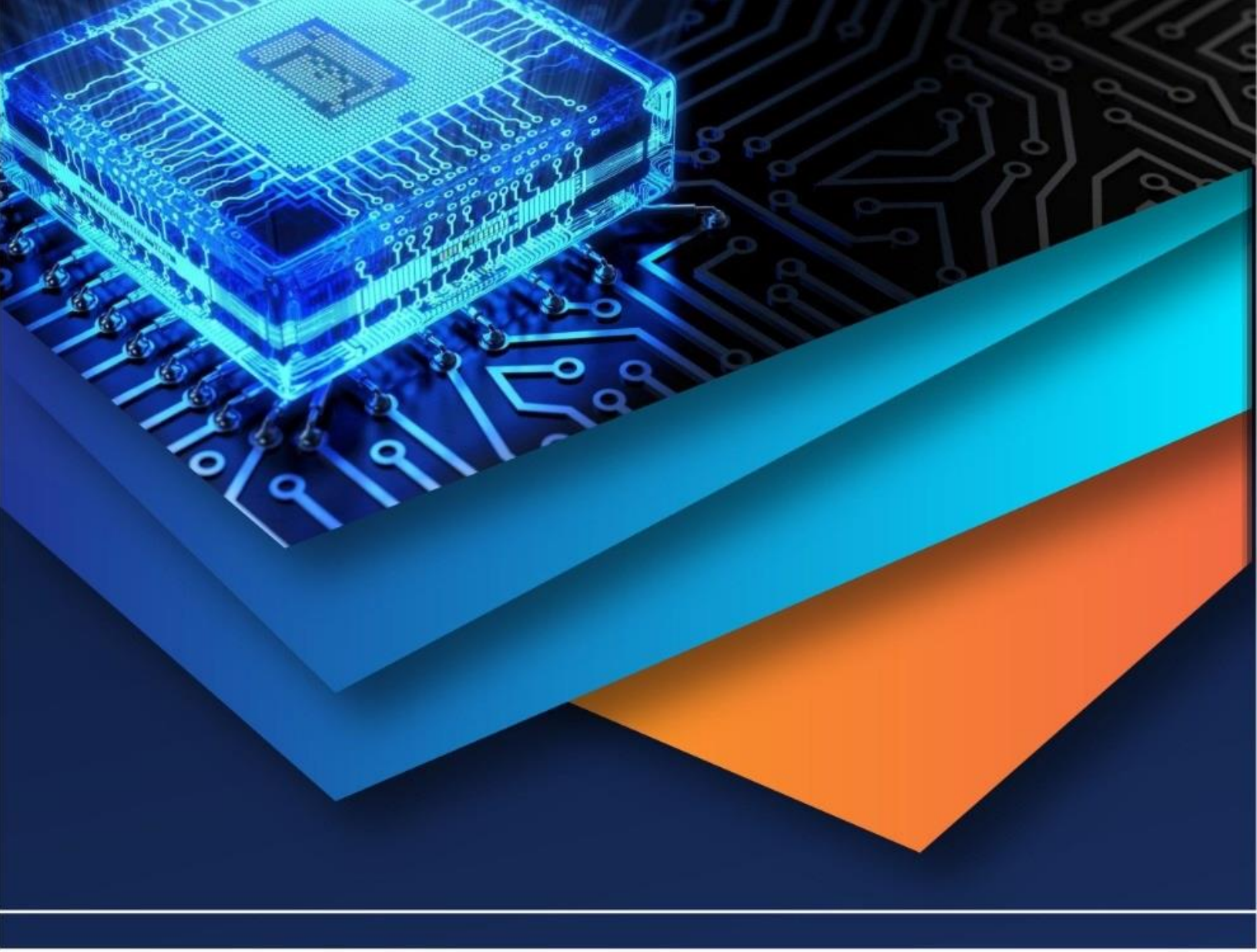

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