Journal of **N**onlinear **A**nalysis and **O**ptimization
Vol. 15, Issue. 1, No.10 : 2024
ISSN : **1906-9685**

Automated Evaluation of Seed Germination Test using CNN and Tensor Flow

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I. ABSTRACT

Assessment of seed germination is an essential task for seed researchers to measure the quality and performance of seeds. Usually, seed assessments are done manually, which is a cumbersome, time consuming and error-prone process. Classical image analyses methods are not well suited for largescale germination experiments, because they often rely on manual adjustments of color-based thresholds. We here propose a machine learning approach using modern artificial neural networks with region proposals for accurate seed germination detection and high-throughput seed germination experiments.

We generated labeled imaging data of the germination process of seeds for three different crops, Zea mays (maize), Secale cereale (rye) and Pennisetum glaucum (pearl millet). Different stateof-the-art convolutional neural network (CNN) architectures with region proposals have been trained using transfer learning to automatically identify seeds within petri dishes and to predict whether the seeds germinated or not.
Our proposed machine learning-based method can help to speed up the assessment of seed germination experiments for different seed cultivars. It has lower error rates and a higher performance compared to conventional and manual methods, leading to more accurate germination indices and quality assessments of seeds

II. INTRODUCTION

Seeds are essential for human society as a food source and serve as starting material for crops. The yield of crops is not only highly dependent on environmental factors but also on the quality of the seed. Therefore, assessment of seed germination is an essential task for seed researchers to measure the performance of different seed lots in order to improve the efficiency of food chains.
In fact it has become imperative as the global crop production must be doubled in order to supply a rising population by 2050. The assessment of seed germination plays a pivotal role in seed research, serving as a critical determinant of seed quality and performance.

However, the conventional manual methods employed for seed assessments are fraught with challenges, characterized by their labor-intensive nature, susceptibility to errors, and time- consuming processes. In response to these limitations, this proposal advocates for a transformative approach utilizing modern artificial intelligence techniques, specifically leveraging convolutional neural networks (CNNs) with region proposals.

By introducing a machine learning paradigm to seed germination detection, this innovative methodology aims to alleviate the drawbacks associated with traditional assessment methods.

The focus is on three distinct crops—Zea mays (maize), Secale cereale (rye), and Pennisetum glaucum (pearl millet)—wherein state-of-the-art CNN architectures, bolstered by transfer learning, are employed to automate seed identification within petri dishes and predict germination outcomes.

This paradigm shift towards a machine learning based methodology not only promises increased efficiency and reduced error rates but also holds the potential to substantially enhance the accuracy of germination indices and quality assessments across diverse seed cultivars.

III. LITERATURE SURVEY

A literature survey for an automated evaluation of seed germination test project would involve reviewing existing research, studies, and relevant literature on topics related to seed germination, automated testing methods, image processing, and data analysis. Below is a general outline to help you structure your literature survey

Seed Germination Process: used for monitoring environmental conditions during seed germination. Investigate the integration of sensors with automated systems.Understand the basic principles of seed germination. Review literature on factors affecting seed germination, such as temperature, light, water, and substrate.

Traditional Seed Germination Testing: Explore existing methods of manual seed germination testing. Review the advantages and limitations of traditional approaches.

Automated Seed Germination Testing: Identify studies or projects that have utilized automation in seed germination testing. Analyze the technologies and methodologies used for automation in seed germination.

Image Processing Techniques: Investigate image processing techniques applied to seed germination analysis. Examine studies that use computer vision for seed germination assessment.

Sensor Technologies: Explore literature on sensors

Data Analysis and Machine Learning: Review literature on data analysis techniques applied to seed germination data. Explore studies that involve machine learning algorithms for predicting seed germination outcomes.

Challenges and Solutions: Identify challenges associated with automated seed germination testing. Investigate proposed solutions and improvements suggested in the literature.

Case Studies and Applications: Look for real-world applications of automated seed germination testing. Explore case studies that demonstrate the effectiveness of automated systems.Future Trends and Research Directions: Discuss emerging trends in automated seed germination testing. Identify gaps in current research and suggest potential areas for future exploration.

IV. METHODOLOGY

Automated evaluation of seed germination tests involves the use of technology and software tools to streamline and enhance the assessment of seed germination. Here is a general methodology for such a project

i. Data Collection:

Seed Preparation: Gather seeds for the germination test. Ensure uniformity in seed selection and preparation.

Experimental Setup: Set up a controlled environment with consistent temperature, humidity, and light conditions.

Image Acquisition: Use a high-resolution camera or imaging system to capture images of the germinating seeds at regular intervals.

Image Preprocessing: Image Preprocessing: Clean and enhance captured images to improve the accuracy of subsequent analysis.

Segmentation: Separate individual seeds from the background and each other in the images.

Feature Extraction: Extract relevant features such as seed size, color, and shape.

Germination Detection: Algorithm Selection: Choose or develop algorithms for germination detection. This may include thresholding, machine learning classifiers, or deep learning techniques.

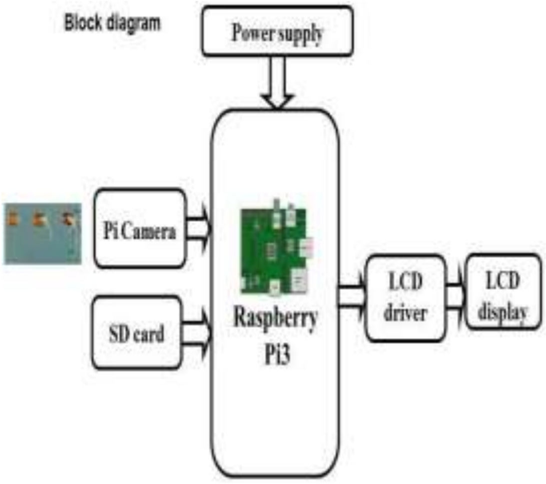
Thresholding: Set appropriate thresholds to differentiate between germinated and non-germinated seeds.

Machine Learning/Deep Learning: Train a model to recognize germination patterns based on extracted features.

ii. Data Analysis:

Quantitative Analysis: Calculate germination percentage, time to germination, and other relevant metrics.

Statistical Analysis: Perform statistical tests to assess the significance of differences between experimental conditions.



iii. Automation Integration:

Workflow Integration: Implement the automated analysis as part of a larger workflow, integrating with hardware and other software components.

Real-Time Monitoring: If applicable, set up real-time monitoring of the germination process and analysis.

iv. Validation and Calibration:

Validation: Validate the automated system against manual assessments and established standards to ensure accuracy.

Calibration: Regularly calibrate the imaging system and algorithms to maintain accuracy over time.

v. Reporting:

Generate Reports: Create automated reports summarizing the results of the germination tests, including visual representations of the data.

Data Visualization: Use graphs and charts to present germination trends and statistical outcomes.

Feedback Loop: Continuous Improvement: Collect feedback from users and stakeholders to identify areas for improvement.

Iterative Development: Continuously update and refine the automated system based on feedback and new requirements.

V. PROPOSED SYSTEM

Seed germination may be defined as the fundamental process by which different plant species grow from a single seed into a plant. This process influences both crop yield and quality. The project aims at designing an automatic monitoring system for seed germination based on image processing OpenCV using raspberry pi and Pi camera. The proposed solution is able to perform the seeds recognition, and germination detection through the images processing. For training the OpenCV Image processing we collect a dataset of images of seed germination process at different stages. To perform this task, Raspberry Pi processor is programmed using embedded 'Linux'. The system contains hardware and software parts, which can independently complete the seed germination test, and can collect seed images in real time during germination test. The image processing algorithm is used to automatically analyze and identify the number of germinated and ungerminated seeds in the current Petri dish and display on LCD display.

Fig 1. Block Diagram

i. DESIGN AND IMPLEMENTATION

The block diagram for the automated evaluation of seed germination tests involves a systematic representation of the various components and stages in the process. At the core of the system is a seed germination chamber, where environmental conditions such as temperature, humidity, and light are precisely controlled to simulate optimal growth conditions. The process begins with the introduction of seeds into the chamber, and sensors continuously monitor key parameters like moisture levels and temperature.The next stage incorporates image acquisition devices, such as cameras or sensors, that capture high-resolution images of the seeds at regular intervals throughout the germination period. These images are then processed through image analysis algorithms, enabling the system to assess crucial germination indicators like radicle emergence, seedling growth, and overall seed vitality.

The automated evaluation of seed germination tests involves a systematic process to accurately assess and quantify the germination potential of seeds. A flow chart is a visual representation that outlines the sequential steps in this automated evaluation process.

The first step in the flow chart involves the setup of the germination test, including the preparation of seeds and the conditions required for germination. This is followed by the initiation of the germination process, typically by exposing seeds to controlled environmental conditions such as temperature, light, and moisture.

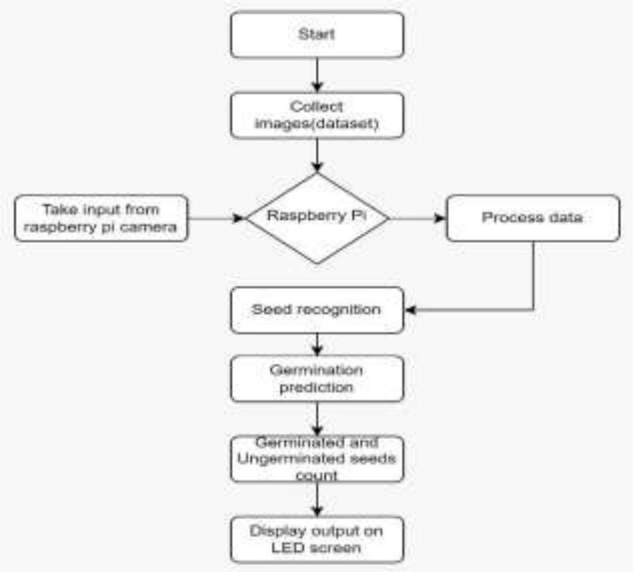


Fig 2. Flow Chart

An automated evaluation system for seed germination tests involves the integration of various electronic components to monitor and assess the germination process efficiently. The circuit diagram for such a system typically includes sensors, microcontrollers, actuators, and display units.

At the core of the circuit is a microcontroller, often Arduino or Raspberry Pi, which acts as the brain of the system. Sensors, such as moisture sensors and temperature sensors, are strategically placed within the germination environment to collect data on soil moisture levels and temperature variations. These sensors feed information to the microcontroller, allowing it to make decisions based on predefined germination parameters. To control the germination environment, the circuit incorporates actuators, which can include heating elements, cooling systems, and water pumps. The microcontroller activates. These actuators as needed to maintain optimal conditions for seed germination. For instance, if the soil moisture drops below a specified threshold, the water pump is triggered to irrigate the seeds.

Additionally, the system may include a feedback mechanism, such as a display unit or data logging module, to provide real-time information on the germination progress. This allows users to monitor the status remotely or analyze the collected data for further insights.

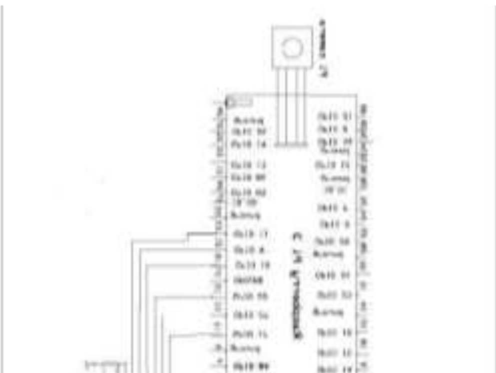


Fig 3. Connections Diagram

Automated evaluation of seed germination tests can offer several advantages, including increased efficiency, accuracy, and consistency in assessing seed viability. Here are some applications for automated evaluation of seed germination tests.

High Throughput Screening: Automated systems can process a large number of seeds quickly, allowing for high-throughput screening of seed batches. This is especially valuable in agricultural research and seed breeding programs.

Data Accuracy and Consistency: Automation reduces the likelihood of human error in seed germination assessments, leading to more accurate and consistent data. This is crucial for maintaining reliable and reproducible results.

Time Efficiency: Automated systems can operate continuously, reducing the time required for germination tests. This is particularly beneficial when dealing with a large volume of seeds or when time-sensitive results are needed.

Fig 4. Implemantation view

Data Logging and Analysis: Automated systems can log and analyze data more efficiently than manual methods. This allows for the tracking of germination patterns over time, facilitating better understanding of seed behavior and performance.

Customized Environmental Conditions: Automated systems can control and monitor environmental conditions such as temperature, humidity, and light, ensuring that germination tests are conducted under standardized and reproducible conditions.

Quality Control in Seed Production: Automated evaluation can be integrated into seed production lines, providing real-time quality control. This ensures that only high-quality seeds are distributed for planting or sale.

Integration with Imaging Technologies: Automated systems can be combined with imaging technologies such as computer vision to capture and analyze seed germination patterns. This can provide detailed information about the germination process, including root and shoot development.

Remote Monitoring: Some automated systems can be monitored and controlled remotely, allowing researchers and seed producers to access data and manage tests from different locations.

Standardization of Testing Protocols: Automated systems help standardize germination testing protocols, reducing variability and ensuring that results are comparable across different experiments and laboratories.

Resource Optimization: Automated systems can optimize the use of resources such as water, space, and energy, contributing to more sustainable and environmentally friendly seed testing practices.

Integration with Seed Health Testing: Automated evaluation can be extended to include seed health testing, helping to identify and eliminate seeds carrying pathogens or diseases.

VI. CONCLUSION:

The project "AUTOMATED EVALUATION OF SEED GERMINATION TEST" was designed a seed germination system using image processing technology. The main controlling device of the project is raspberry pi processor. pi camera and LCD display is interfaced to the raspberry pi. When the pi camera capture image this fed as same to the raspberry pi then raspberry pi process this image and count the number of germinated and ungerminated seeds will be display on LCD. Integrating features of all the hardware components used have been developed in it. Presence of every module has been reasoned out and placed carefully, thus contributing to the best working of the unit. Secondly, using highly advanced IC's with the help of growing technology, the project has been successfully implemented. Thus, the project has been successfully designed and tested.

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