IDENTIFICATION OF WHEAT STEM RUST USING MACHINE LEARNING TECHNIQUE – A SVM BASED APPROACH

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ABSTRACT

This study proposes an efficient method for early detection of fungal diseases in wheat crops using image processing and machine learning. The system classifies wheat leaves into two categories: Black rust (stem rust) and Healthy. Images are first pre-processed through resizing to ensure uniformity, followed by feature extraction using Histogram of Oriented Gradients (HOG) to capture texture and shape characteristics. A Support Vector Machine (SVM) classifier is trained on labelled data to perform classification. Model performance is evaluated using confusion matrix–based metrics, including accuracy, precision, recall, and F1-score. Results indicate that the SVM model achieves high classification accuracy, demonstrating its effectiveness as a decision-support tool for early disease detection, enabling timely intervention and improved crop productivity.

Keywords: agriculture, image processing, SVM, machine learning

I. INTRODUCTION

Plant diseases remain a significant challenge to global agriculture, leading to substantial reductions in crop yield and quality. Wheat, being one of the most widely cultivated staple crops, is particularly vulnerable to fungal infections such as Black rust (stem rust), caused by *Puccinia graminis f. sp. tritici*. This disease is highly destructive and capable of causing severe yield losses if not detected at an early stage. Conventional disease detection methods rely on manual inspection by experts, which is often time-consuming, labor-intensive, and prone to subjective errors. Consequently, there is a growing need for automated, accurate, and scalable solutions for early disease detection.

Recent advancements in image processing and machine learning have provided effective alternatives for plant disease identification. These techniques enable automated analysis of crop images, offering improved accuracy, consistency, and speed compared to traditional approaches. In this study, an efficient method is proposed for the early detection of fungal diseases in wheat crops through image-based classification. The system focuses on categorizing wheat leaf images into two classes: Black rust (stem rust) and Healthy, which is essential for timely disease management and prevention of crop loss.

The proposed methodology involves preprocessing input images by resizing them to a standard resolution to ensure uniformity in feature extraction. Subsequently, Histogram of Oriented Gradients (HOG) features are extracted to capture the texture and structural characteristics associated with disease symptoms. These features are then used to train a Support Vector Machine (SVM) classifier, a supervised learning model known for its effectiveness in high-dimensional feature spaces and binary classification tasks. The trained classifier is employed to predict the class of unseen input images.

The performance of the proposed model is evaluated using confusion matrix–based metrics, including accuracy, precision, recall, and F1-score, which provide a comprehensive assessment of classification performance. Experimental results demonstrate that the SVM-based approach achieves high accuracy and reliability, indicating its suitability for practical deployment.

Overall, the integration of image processing and machine learning techniques in this study provides a robust framework for early detection of wheat diseases. The proposed system has the potential to assist farmers and agricultural experts in making timely decisions, thereby reducing crop losses and improving agricultural productivity.

II. LITERATURE SURVEY

Several researchers have explored the application of image processing and machine learning techniques for plant disease detection. Bharate and Shirdhonkar [1] presented a review of image processing–based methods, emphasizing their role in reducing reliance on manual monitoring. Zhao et al. [2] developed a GIS-based system integrated with artificial neural networks (ANN) for effective prediction and management of apple diseases.

Deep learning approaches have also gained attention for their high accuracy. Geetharamani and Pandian [3] proposed a deep convolutional neural network (CNN) model for plant leaf disease identification, achieving improved performance through data augmentation techniques. Similarly, El Houby [4] reviewed various machine learning techniques, including ANN, KNN, and decision trees, highlighting their effectiveness in disease prediction and management.

In addition, Yang et al. [5] discussed the use of decision tree algorithms for image classification in remote sensing applications, demonstrating their efficiency and flexibility. Ebrahimi et al. [6] applied a support vector machine (SVM)–based approach for pest detection, achieving high classification accuracy using image-derived features.

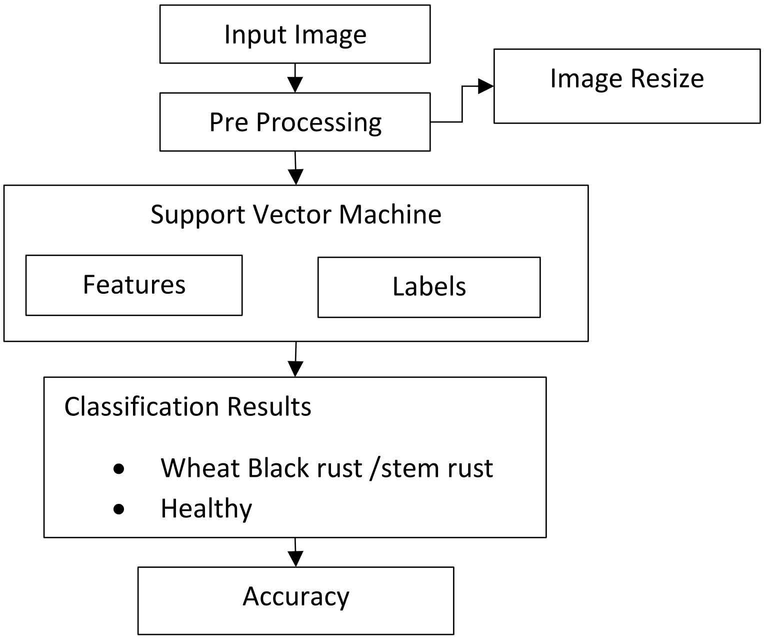
Although deep learning models provide high accuracy, they often require large datasets and high computational resources. In contrast, traditional machine learning techniques such as SVM offer a good balance between accuracy and computational efficiency. Therefore, this study adopts an SVM-based approach combined with HOG feature extraction for effective wheat disease detection.

III. PROPOSED METHOD

The proposed system integrates image processing and machine learning techniques for the early detection of fungal diseases in wheat leaves. Initially, input images are collected and pre-processed by resizing them to a fixed resolution (256×256) to ensure uniformity and reduce noise. This step improves the consistency of further analysis.

Feature extraction is performed using Histogram of Oriented Gradients (HOG), which captures important texture, edge, and shape information related to disease symptoms such as spots and lesions. The extracted features are then used to train a Support Vector Machine (SVM) classifier. The dataset is divided into training (70%) and testing (30%) sets to build and evaluate the model.

The working principle of SVM is based on finding an optimal decision boundary (hyperplane) that separates the data into two classes: Healthy and Black rust infected leaves. The algorithm selects support vectors and maximizes the margin between the classes to achieve accurate classification. Once trained, the model predicts the class of new input images.



Finally, the system performance is evaluated using confusion matrix–based metrics such as accuracy, precision, recall, and F1-score, ensuring reliable and efficient disease detection.

IV. SOFTWARE DESCRIPTION

MATLAB:

The name MATLAB stands for Matrix Laboratory. The software is built up around vectors and matrices. This makes the software particularly useful for linear algebra but MATLAB is also a great tool for solving algebraic and differential equations and for numerical integration. MATLAB has powerful graphic tools and can produce nice pictures in both 2D and 3D. It is also a programming language, and is one of the easiest programming languages for writing mathematical programs. These factors make MATLAB an excellent tool for teaching and research.

MATLAB was written originally to provide easy access to matrix software developed by the LINPACK and EISPACK projects. It integrates computation, visualization, and programming environment. Furthermore, MATLAB is a modern programming language environment: it has sophisticated data structures, contains built-in editing and debugging tools, and supports object-oriented programming. MATLAB has many advantages compared to conventional computer languages (e.g., C, FORTRAN) for solving technical problems.

MATLAB abilities a family of add-on software program utility software application software program software utility software-unique solutions called toolboxes. Very essential to maximum customers of MATLAB, toolboxes assist you to studies and observe specialized technology. Toolboxes are entire collections of MATLAB abilities (M-files) that increase the MATLAB surroundings to remedy precise schooling of problems. Areas in which toolboxes are to be had embody signal processing, manipulate systems, neural networks, fuzzy correct judgment, wavelets, simulation, and hundreds of others.

It has powerful built-in routines that enable a very wide variety of computations. It also has easy to use graphics commands that make the visualization of results immediately available. Specific applications are collected in packages referred to as toolbox. There are toolboxes for signal processing, symbolic computation, control theory, simulation, optimization, and several other fields of applied science and engineering. MATLAB is an interactive system whose basic data element is an array that does not require dimensioning. The software package has been

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commercially available since 1984 and is now considered as a standard tool at most universities and industries worldwide.

Uses of MATLAB:

MATLAB is widely used as a computational tool in science and engineering encompassing the fields of physics, chemistry, math and all engineering streams. It is used in a range of applications including

- Signal Processing and Communications
- Video and Video Processing
- Control Systems
- Test and Measurement
- Computational Finance
- Computational Biology

V. RESULT

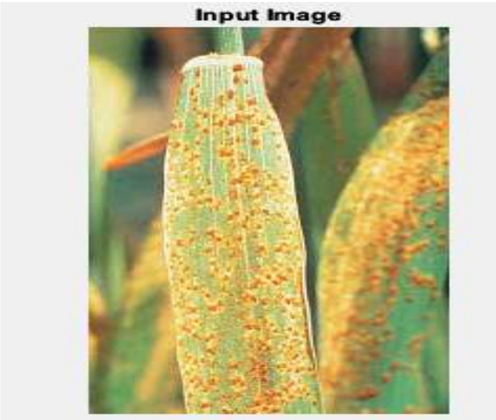

Fig: Input Image

Fig: Resize Image

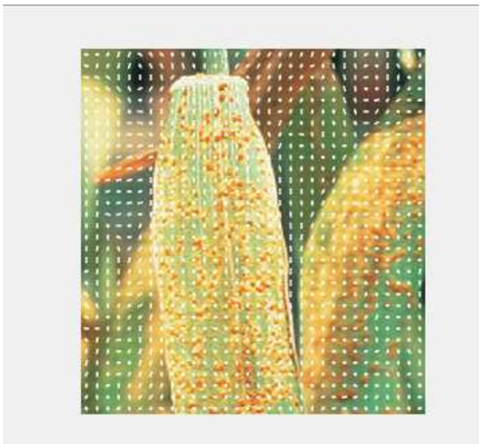

Fig: HOG Features

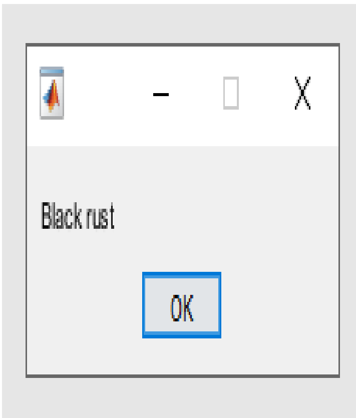

Fig: Classification Results

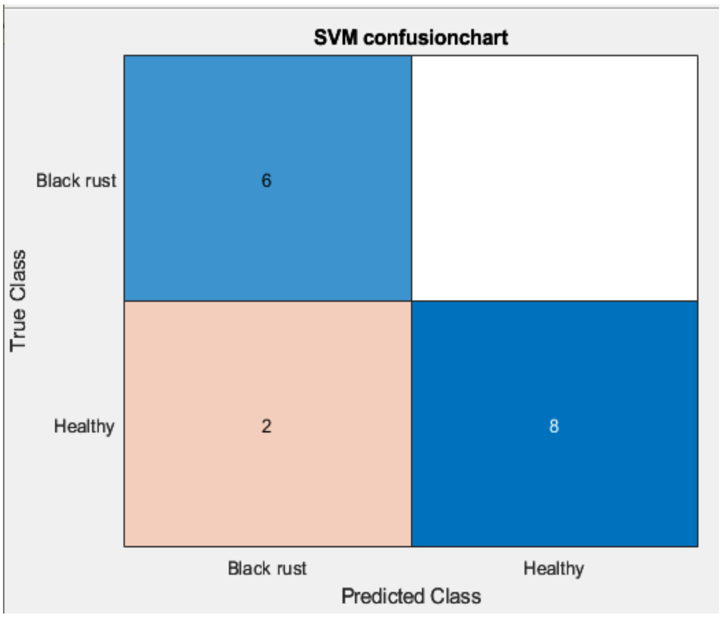

Fig: Confusion Chart

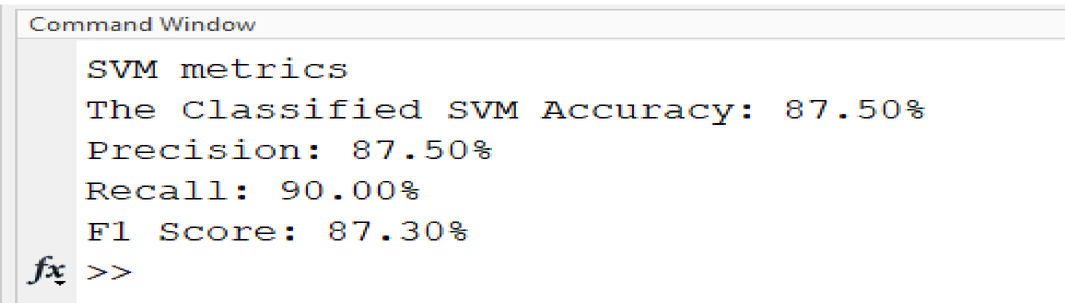

Fig: Metric Values

VI. CONCLUSION

This study demonstrates the effectiveness of image processing and machine learning techniques for early detection of wheat fungal diseases. Using HOG features and an SVM classifier, the system accurately classifies Black rust and healthy leaves. Performance evaluation shows high accuracy and reliability, making it a useful tool for automated disease detection. The approach reduces dependency on manual inspection and supports timely crop management. Future improvements can include deep learning and IoT integration for large-scale real-time monitoring.

VII. REFERENCES

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