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Identification of Black Mold Disease in Tomato using Fuzzy Inference System

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***Abstract**: Tomato is most commonly grown vegetable in all over the world. Tomato is used in many ways as a constituent such as sauces, pickles, salads, and drinks etc[1]. Tomatoes get easily infected as they are susceptible to temperature. It can be infected through many diseases like bacteria, virus, and fungus etc[2]. Black mold disease is caused by the fungus alternaria alternata. This fungus generally attacks to ripe tomatoes as well as those who are kept free in moisture also. Symptoms of black mold disease are tiny brown color spot on the surface which get turn into big hollow, deep set on lesion of tomato. The aim of this paper is to analyze the work of different researchers who have applied the fuzzy inference system (fis) for disease detection. This research work also includes the result of hybrid approach of backpropagation neural network (bpnn) and genetic algorithm (ga) which has been applied for detection of black mold disease in tomato. The result of this hybrid approach can be improved by applying the fuzzy inference system classifier. This research paper gives a general approach for detection of black mold disease in tomato using fuzzy inference system classifier.*
Keywords: fuzzy inference system, backpropagation neural network, genetic algorithm.

I. INTRODUCTION

Tomato (Solanum lycopersicum) is edible red color type fruit which comes under the category of nightshade family, Solanaceae. Tomato is generally found in the countries namely India, Peru, South America, Spain, Morocco, Mexico, Turkey, and etc. Tomato belongs to Vitamin C and A category. It is used as a constituent such as dishes, pickles, sauces, salads, drinks and etc[1]. It is very sensitive to temperature and gets easily infected through many diseases like fungus, bacteria, virus and etc. Tomato can be affected from soil, water supply, air, infected tools, animals, and gardeners. Four parts of the tomato plant can be affected: leaves, stem, crown and root.

A. Types of Tomato Diseases

Tomato gets infected generally due to fungus, bacteria and virus. Following are some diseases listed out:

1) *Fungus Based Tomato Diseases:* Tomatoes infected due to fungus and it is mostly transmitted through air. Some diseases are listed below which comes under this category:
2) *Blights:* It is of two type i.e. early blight and late blight. Early blight is found on the leaves with small black lesion and late blight is found on the crown of the fruit [4]. Fig 1.1 depicts this disease.
3) *Black Mold:* Occurs due to Alternaria alternate fungi. It generally found on the ripe tomato which exposed to free moisture [3]. Fig 1.2 shows this disease.


Fig 1.1: Early Blight


Fig 1.2: Black Mold

4) *Bacterial Based Tomato Diseases:* This disease is found in tomato due to bacteria. Following are the some disease:
5) *Bacterial Speck:* Small black spot occurs on the lesion of the tomato fruit which can be removed easily by scrapping with fingernail [5]. This disease is shown in Fig 1.3.
6) *Bacterial Spot:* Small, pimple like spot, dark brown, scabby, sunken or slightly raised spots seems as the symptoms on the tomato fruit [5]. Figure 1.4 shows this disease.

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Fig 1.3: Bacterial Speck Fig 1.4: Bacterial Spot

7) *Virus Based Tomato Diseases:* This disease is found in tomato due to virus. Following are the some disease:

a) *Tomato Mosaic Virus:* Yellow blotches and necrotic spots are symptoms of this disease and which occurs on both ripe and green fruit [5]. Figure 1.5 shows this disease



Fig 1.5: Tomato mosaic virus

B. Black Mold Disease in Tomato

Black Mold disease is occurs in tomato because of fungus named Alternaria alternata. This disease is mostly found in hilly areas. Black Mold disease generally attacks to the ripe tomatoes which are openly kept to the moisture. It is mostly found on the crown of the tomato fruit. This disease may found on ripe fruit as well as green fruit also. Symptoms can be vary from tiny, superficial, brown flecks to big, sunken, black lesions on the surface of the tomato fruit. This fungus is known as weak pathogen because it damages the moribund tissue only and it can be seen on the lesions of the ripe tomato fruit [3].

C. Soft Computing

Soft computing was proposed by L.A. Zadeh. Soft computing is a methodology that use the tolerance for imprecision and uncertainty for obtaining the tractability, robustness and low solution cost [6]. The methods which are involved in soft computing are Fuzzy Logic(FL), Neural Network (NN), Support Vector Machines (SVM), Evolutionary Computation (EC), Machine Learning (ML) and Probabilistic Reasoning (PR) etc. Unpredictable, uncertain and the values lies between 0 & 1 are the solutions of the Soft computing (SC). Applications of soft computing are handwritten recognition, automotive systems and manufacturing, image processing and data compression, architecture etc.

1) *Fuzzy Logic (FL):* FL are one of the form of Soft Computing which adapt the imprecision of the real world. It is the extension of multivalued logic whose aim is to estimate the reasoning solution rather than exact solution. The truth value of fuzzy logic may lie in the range between 0 &1 [6].

2) *Fuzzy Inference System (FIS):* Fuzzy inference is one the main application of fuzzy logic. The basic idea of Fuzzy inference is to take input variable and then reach out to the output space by using the fuzzy logic mechanism which is contains If-Then rules, membership functions and fuzzy logic operations. There are three types of fuzzy inference system: Mamdani fuzzy inference, Sugeno fuzzy inference, and Tsukamoto fuzzy inference [7]. Fig.1.6 shows the basic block diagram of Fuzzy Inference System (FIS) [8]. Fuzzification is the process of converting the numeric or crisp value into fuzzy set. Defuzzification is the reverse process of fuzzification, in which fuzzy set in converted into numeric or crisp set [9].

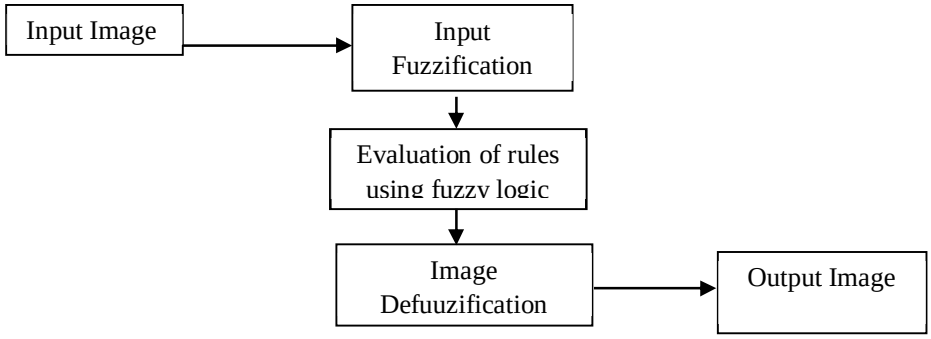


Fig 1.6: Basic Block Diagram of Fuzzy Inference System

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II. EXPERIMENTAL DETAILS AND METHOD

A. Experimental Details

Different types of techniques were applied by different researchers for identifying the diseases. In this section we have reviewed to those papers who have applied Fuzzy Inference System (FIS) for detection of disease.

[Mohammed Y. Kamil et.al.2014] presents a edge detection algorithm using Fuzzy Inference System (FIS).This algorithm detects the edges of digital image in which three inputs were given by using Gaussian membership function and one output has been generated by using Triangle membership function that represents the pixel values whether as "Low", "Medium" or "High". Author has applied the Mamdani FIS to the 3×3 image and then this result was compared with Canny edge detection method. Both the algorithm was compared on the basis of PSNR performance value and the experimental values shows that the proposed algorithm gave the higher PSNR values as compared to Canny Edge Algorithm [10].

[K. Muthukannan et.al. 2014] detects the unhealthy region of plant leaf image by applying Fuzzy Inference System (FIS) .They were used 100 training dataset of single leaf and more than 20 samples were tested. Initially the color images of leaf were taken and from which the two features are extracted i.e. mean and standard deviation. Then these extracted were applied to Fuzzy Inference System for classification of healthy, unhealthy and slightly unhealthy leaf image. The accuracy of this classifier is 95% [9].

[Kianaz Rezaei et. al. 2014] proposed a Soft Computing model for the problem of peptic ulcer assessment. Author's aim was to utilize the techniques of Soft Computing for managing the uncertainty and imprecision in terms of size and shape of abnormal images. In this research, Fuzzy Inference System (FIS) technique was applied which is one of the types of Soft Computing. Fuzzy Inference System (FIS) imitates the procedure of human decision in detection and analysis of peptic ulcer. Fuzzy Inference System was applied for the assessment of severity of peptic ulcer. The FIS performance result shows the accuracy of 98.1% [11].

[Mustain Billah et. al. 2015] proposed a Tea leaf disease recognition system .In this research, Adaptive neuro fuzzy inference system (ANFIS) was applied for detection of Tea leaf disease by extracting the color wavelet features. Initially, the tea leaf image was taken as dataset from which color features extracted and provided to Adaptive neuro fuzzy inference system (ANFIS). For the experimental purpose, the training and testing samples were taken as 45 & 30 respectively. The result shows that one third of the data samples are disease affected and rest are unaffected. The accuracy of this system was 95.7% [12].

[Victor E. et. al. 2013] presents a system for prediction of risk levels of depression by applying the Fuzzy Inference System (FIS). Depression is the major health problem in the worldwide. In this paper, authors present a FIS model which gave support to the physicians for diagnosis of the disease. The FIS model determines the depression risk levels with 100% accuracy for 'Near absent' and 'Mild' cases respectively. It also recognizes the cases of 'Moderate', 'Severe' and 'Very Severe' with 84%, 92% and 94% accuracy respectively. This research shows the result that Fuzzy Logic is sensitive and it is useful for medical purpose also [13].

[Sapna Thakur et.al. 2015] proposed a new approach which is based on Fuzzy Inference System (FIS) for detection of Thalassemia disease which is found in patients. Total 40 patients were taken as dataset for the inspection in which randomly 15 patients dataset used for testing the accuracy of the system. Overall accuracy of the system was 80% [14].

[Sivagowry S et.al. 2015] proposed an intelligent system which is based on Fuzzy Inference System to prophesy the savagery of Cardio Vascular disease. It is a disease from which one can lead to very bad disability and death. An intelligent Fuzzy Inference System (FIS) was made for diagnosis of heart disease. Experimental result shows an accuracy of 95.23% [15].

B. Method

For detection of diseases many researchers has done many research work by applying the different approaches. As researcher's main aim is to obtain the classifier that gives the best accuracy or result. In this research work, analysis of different research work is done for obtaining the best classifier.

C. General Approach

By reviewing the work of different researchers, it is found that Fuzzy Inference System (FIS) gives the best result for detection of disease. For identification of Black Mold disease in tomato work has been done by applying the image processing techniques but for achieving the more accurate result, Fuzzy Inference System (FIS) classifier can be applied. The general approach is shown in Figure 2.1 below for detection of Black Mold disease in tomato.

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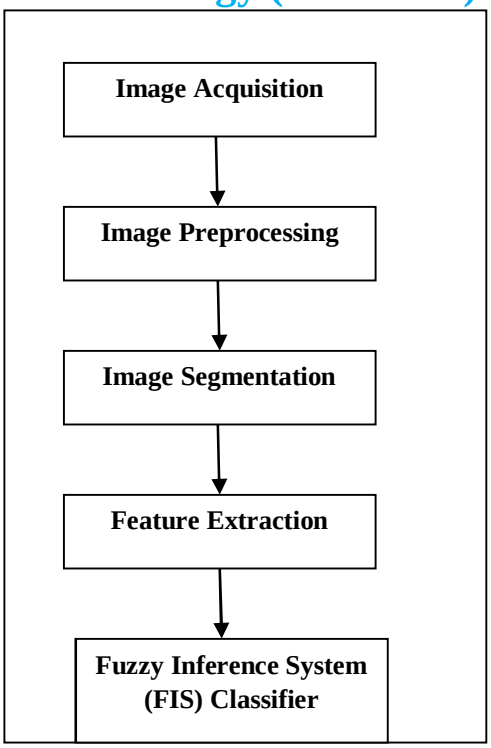


Fig.2.1: General Approach for Detection of Black Mold Disease in Tomato

1) *Image Acquisition:* Images of Infected and non-infected tomato fruit are acquired through digital camera [16].
2) Image Preprocessing- Image preprocessing involves image cropping, image converting, remove noises and image enhancement etc [16].
3) *Image Segmentation:* Segmentation is the process of subdividing an image into constituent regions or objects. Different techniques which are involved in segmentation are K-Means Clustering, Fuzzy C-Mean Clustering, Thresholding, Region Growing etc [16].
4) *Feature Extraction:* Feature extraction is the technique of extracting the features such as color, texture and shape etc. from the segmented image [16]..
5) *Fuzzy Inference System (FIS) Classifier:* Fuzzy inference System (FIS) is the technique of mapping given input variables and then reach out to the output space by using the fuzzy logic which contains If-Then rules, membership functions and fuzzy logic operations. Types of fuzzy inference system are: Mamdani fuzzy inference, Sugeno fuzzy inference, and Tsukamoto fuzzy inference [7].

III. OBSERVATION & RESULTS

Table 3.1 shows the comprehensive details of some research work. This table analyzes the performance of various research works for detection of disease.

TABLE 3.1 Comparison and Performance analysis of Disease Identification & Classification using Fuzzy Inference System (FIS)

S. No.	Disease/Deficiency/ Damage	Methodology Used	Accuracy or Result	References
1.	Cardio Vascular Disease	Detects the severity of disease by using Fuzzy Inference System (FIS)	95.23%	Sivagowry S et.al. 2015
2.	Edge Detection in digital images	Proposed a novel edge detection using Fuzzy Inference System (FIS)	Satisfactory result (Above 90%)	Mohammed Y. Kamil

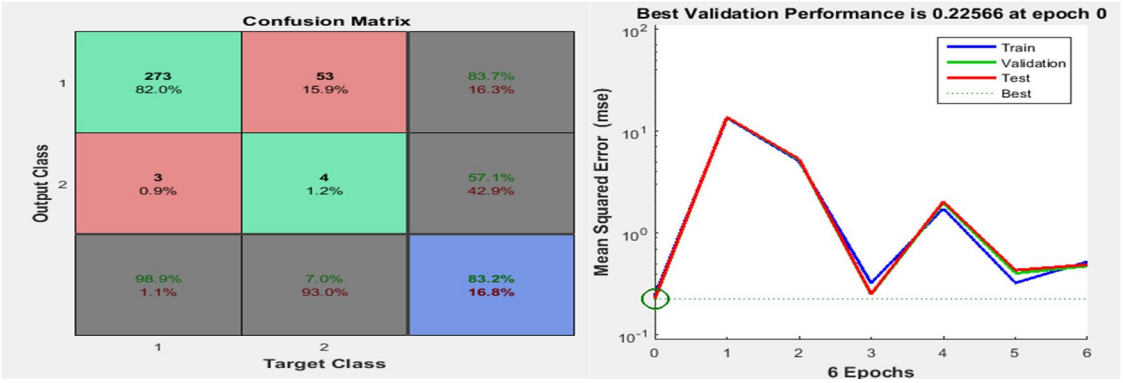
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3.	Unhealthy region in plant leaf	Detects the unhealthy region of plant leaf image by applying Fuzzy Inference System (FIS)	95%	K. Muthukannan et. al. 2014
4.	Peptic Ulcer	In this research, Fuzzy Inference System (FIS) technique was applied; (FIS) imitates the procedure of human decision in detection and analysis of peptic ulcer.	98.1%	Kianaz Rezaei et. al. 2014
5.	Tea leaf Disease	In this research, Adaptive neuro fuzzy inference system (ANFIS) was applied for detection of Tea leaf disease by extracting the color wavelet features.	95.7%	Mustain Billah et. al. 2015
6.	Prediction of risk levels of depression	Proposed a system for prediction of risk levels of depression by applying the Fuzzy Inference System (FIS).	94%	Victor E. et. al. 2013
7.	Thalassemia disease	Proposed a new approach which is based on Fuzzy Inference System (FIS) for detection of Thalassemia disease which is found in patients	80%	Sapna Thakur et.al. 2015
8.	Breast Cancer	Proposed two detection system for detecting the microcalcifications and masses by applying Mamdani inference system.	Satisfactory result (Above 90%)	S. Auephanwiriyakul et. al.2005
9.	Osteosclerosis detection in the bone section of the joints of hand and knee	Aim is to analyze the medical x-ray image and then after segmentation ,it is applied to the Fuzzy Inference System(FIS)	78.64%	Norbert Gal et.al. 2013
10.	Orchid disease in leaf	Proposed a system to detect the disease using image processing and fuzzy inference system	Satisfactory result(Above 90%)	Muhammad Thaqif bin Mohamad Azmi et.al.2013

Black Mold disease in tomato was detected using Image Processing & SoftComputing techniques[17].This research work aim is to obtain the optimized classifier for detection of Black Mold disease in tomato.Fig.3.1 & 3.2 shows the Confusion Matrix and Performance plot of BackPropagation NeuralNetwork and Combination of BackPropagation NN & Genetic Algorithm.

The result shows an efficiency of BackPropagation NN and BackPropagation NN &Genetic Algorithm (BPNN-GA) for detection of Black Mold disease in tomato is 83.2% and 87.4% respectively [17] . The efficiency can be improved by applying the Fuzzy Inference System (FIS) classifier.

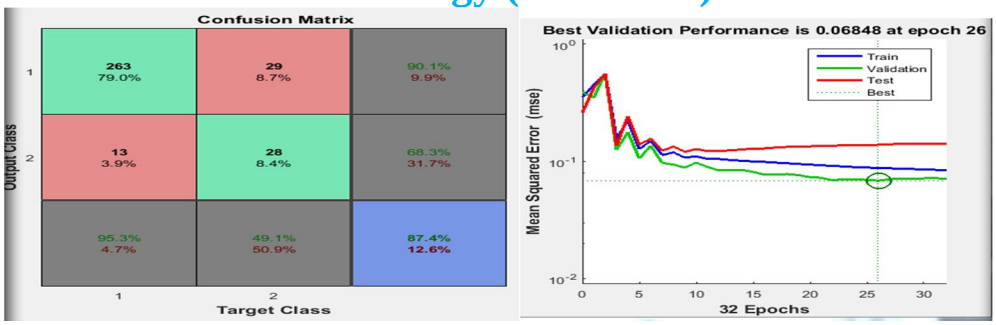


(a) Confusion Matrix of Backpropagation NN (b) Performance Plot of Backpropagation NN

Fig.3.1: Confusion Matrix and Performance Plot of Backpropagation NN

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(c)Confusion Matrix of BPNN & Genetic Algorithm (d) Performance Plot of BPNN & Genetic Algorithm

Fig.3.2: Confusion Matrix and Performance Plot of BPNN & Genetic Algorithm

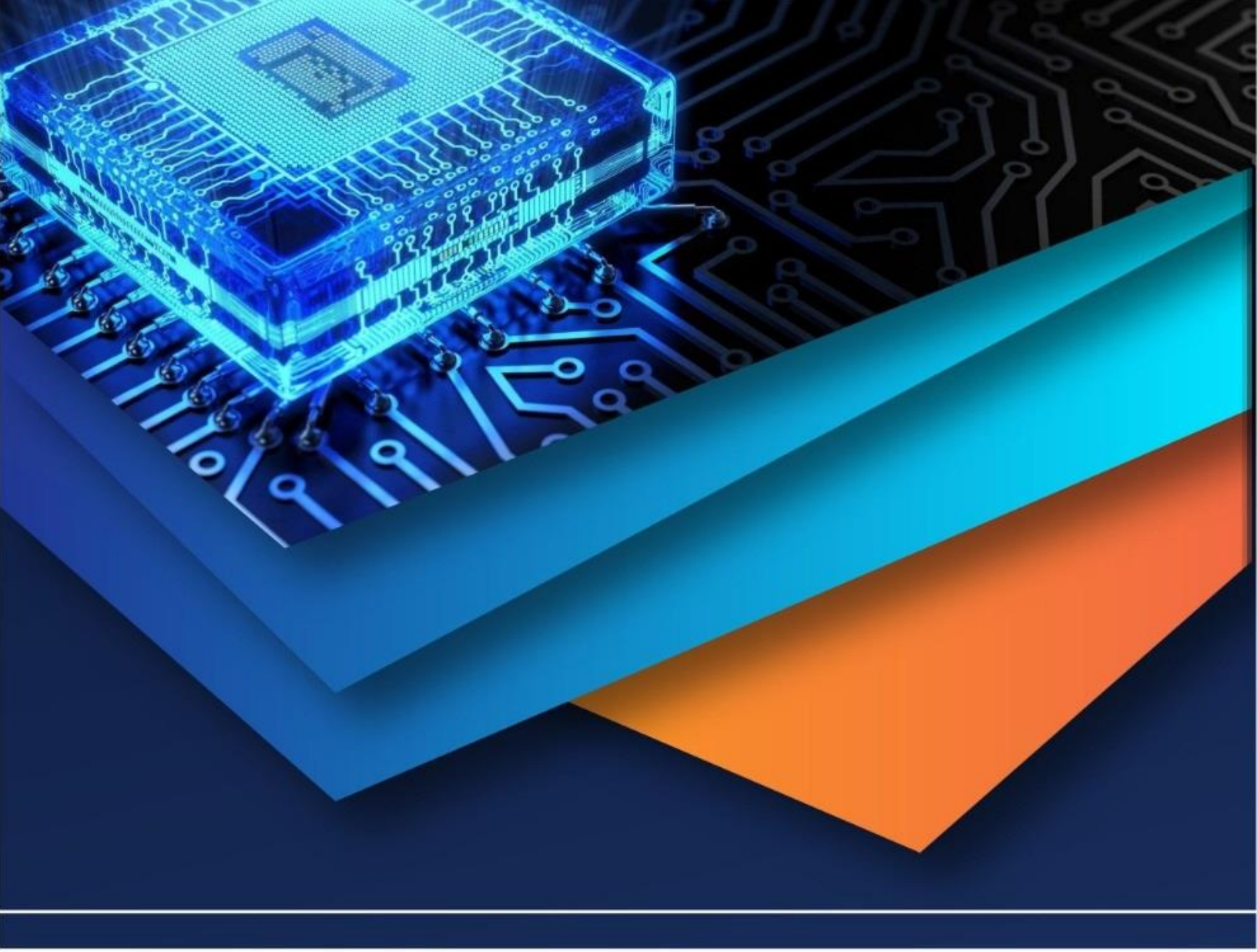
IV. DISCUSSION & FUTURE SCOPE

This research work is performed to review and summarizes the work of different researchers who have done in the field of Fuzzy Inference System (FIS).By reviewing some of the important work, it has been concluded that FIS classifier gives the efficient result with best accuracy. As work is done on Black Mold disease detection in tomato using different classifiers but to improve the efficiency of the result, Fuzzy Inference System (FIS) classifier can be applied.

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