# WEED DETECTION IN SOYABEANS CROPS

A Course Project report submitted

in partial fulfillment of the requirement for the award of degree

**BACHELOR OF TECHNOLOGY**

in

**ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING**

by


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# CERTIFICATE

This is to certify that the project entitled **"WEED DETECTION IN SOYABEENS CROPS"** is the bonafide work carried out by **K.Preetham, G.Sai Krishna** as a Course Project for the partial fulfillment to award the degree **BACHELOR OF TECHNOLOGY** in **ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING** during the academic year 2022-2023 under our guidance and Supervision.


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# ACKNOWLEDGEMENT

We express our thanks to Course co-coordinator **Mr. D.Ramesh, Asst. Prof.** for guiding us from the beginning through the end of the Course Project. We express our gratitude to Head of the department CS&AI, **Dr. M.Sheshikala, Associate Professor** for encouragement, support and insightful suggestions. We truly value their consistent feedback on our progress, which was always constructive and encouraging and ultimately drove us to the right direction.

We wish to take this opportunity to express our sincere gratitude and deep sense of respect to our beloved Dean, School of Computer Science and Artificial Intelligence, **Dr C. V. Guru Rao**, for his continuous support and guidance to complete this project in the institute.

Finally, we express our thanks to all the teaching and non-teaching staff of the department for their suggestions and timely support.

# ABSTRACT

Weed management is a significant challenge in agriculture, as weeds compete with crops for nutrients, sunlight, and water, leading to reduced crop yield and quality. Traditional methods of weed control involve manual labour, herbicide application, and tillage practices, which can be expensive, time-consuming, and have adverse effects on the environment. In recent years, there has been an increasing interest in the use of machine learning algorithms and computer vision techniques for weed detection in crop fields. This report focuses on weed detection in soybean crops using computer vision techniques. The use of computer vision techniques for weed detection in soybean crops enables the detection of weeds at an early stage, which allows for timely intervention and reduces the likelihood of yield losses. Computer vision techniques can also be used to differentiate between different types of weeds and enable targeted weed control, which reduces the use of herbicides and minimizes the environmental impact. This report discusses the different computer vision techniques used for weed detection in soybean crops, their advantages and limitations, and future research directions in this area.

# Table of Contents

# INTRODUCTION

## 1.1 OVERVIEW

The report on weed detection in soybean crops aims to investigate the various techniques and methods available for detecting and controlling weeds in soybean crops. Weeds are a major concern for farmers as they compete for nutrients, water, and light, reducing crop yields and affecting crop quality. The report will provide an overview of the various types of weeds that can affect soybean crops and their impact on yield and quality. It will also discuss the traditional weed detection and control methods, including hand weeding and herbicides, and their limitations.

The report will focus on emerging technologies for weed detection and control, including remote sensing, machine learning, and robotics. The use of drones equipped with cameras and sensors for weed detection and mapping will also be explored. The report will examine the advantages and limitations of each of these technologies and their potential impact on soybean crop management.

In addition to discussing the various technologies for weed detection, the report will also explore the economic and environmental implications of weed management strategies. The report will consider the cost-benefit analysis of using different weed management techniques and the potential environmental impact of herbicide use.

Finally, the report will provide recommendations for farmers and stakeholders in the agricultural industry on the best practices for weed detection and control in soybean crops. The report will highlight the importance of integrating multiple technologies and strategies for effective weed management and maximizing crop yields and quality.

## 1.2 PROBLEM STATEMENT

Weeds are a significant problem for soybean farmers worldwide, as they compete with soybean crops for essential resources such as nutrients, water, and light, leading to reduced crop yield and quality. Traditional weed control methods, such as hand weeding and herbicide application, have limitations and may not be effective in managing weeds in large fields.

There is a need to explore emerging technologies and techniques for weed detection and control in soybean crops to improve weed management strategies and maximize crop yield and quality. However, comprehensive research on the various technologies available and their effectiveness in soybean crop management is lacking.6

Therefore, the problem statement for this report is to investigate the current state of weed detection and control in soybean crops, evaluate the emerging technologies and techniques for weed management, and provide recommendations for effective weed management

strategies for soybean farmers and stakeholders. The report aims to fill the research gap and provide valuable insights into the latest developments in weed detection and control in soybean crops.

## 1.3 EXISTING SYSTEM

The existing system for weed detection and control in soybean crops primarily relies on traditional methods such as hand weeding and herbicide application. These methods are labour-intensive, time-consuming, and may not be effective in managing weeds in large fields.

1. Hand weeding involves manually removing weeds by pulling them out of the soil. While this method is effective, it is labour-intensive, time-consuming, and may not be feasible for large-scale farming operations.

2. Herbicide application involves applying chemical substances that kill or suppress weeds. Herbicides can be selective, targeting specific types of weeds, or non-selective, affecting all types of plants. While herbicides are effective in controlling weeds, they can also have negative environmental impacts, such as soil and water pollution.

3. Remote sensing technologies, such as satellite and aerial imagery, have also been used for weed detection in soybean crops. These technologies can provide data on plant growth, vegetation health, and weed infestations. However, the accuracy of remote sensing for weed detection in soybean crops may be limited by factors such as cloud cover, crop density, and crop growth stage.

## 1.4 PROPOSED SYSTEM

The proposed system for weed detection in soybean crops

Image Acquisition: The system should acquire images of the soybean crop and the surrounding weed plants using a high-resolution camera mounted on a drone or a ground-based device.

Pre-processing: The acquired images must undergo pre-processing to remove noise and enhance the features of the crop and weed plants. Techniques like median filtering, morphological operations, and image thresholding can be used.

Segmentation: The next step is to segment the pre-processed image into different regions corresponding to the crop and weed plants. This can be done using techniques like clustering, thresholding, or deep learning-based segmentation.

Feature Extraction: After segmentation, relevant features such as color, texture, shape, and size can be extracted from each region to distinguish between the crop and weed plants

Weed Detection: Based on the extracted features, a classification model can be trained to distinguish between crop and weed plants. The model can be based on traditional machine learning algorithms or deep learning approaches like convolutional neural networks (CNNs).

Weed Removal: Once the weed plants are detected, the system can control a mechanical or chemical weed removal mechanism to remove the weed plants.

Monitoring and Feedback: The system can continuously monitor crop and weed growth and provide feedback to the farmer or agronomist. The feedback can help in making informed decisions about crop management practices.

## 1.5 OBJECTIVES

The objectives of weed detection in soybeans crops are:

- Introducing the problem: The report should start by introducing the problem of weed infestation in soybean crops, the impact it can have on crop yield and quality, and the traditional methods used for weed control.
- Presenting the proposed solution: The report should explain the proposed system for weed detection in soybean crops using image processing techniques, its working principle, and the advantages it offers over traditional methods.
- Describing the system components: The report should describe each component of the proposed system, such as image acquisition, pre-processing, segmentation, feature extraction, weed detection, and weed removal.
- Discussing the methodology: The report should explain the methodology used to develop the weed detection model, including the dataset used, the feature selection process, the model selection process, and the evaluation metrics.
- Presenting the results: The report should present the results of the weed detection model, including its accuracy, sensitivity, specificity, and other performance measures.
- Discussing the limitations: The report should discuss the limitations of the proposed system, such as its dependence on image quality, environmental conditions, and the need for periodic calibration.
- Outlining the future work: The report should outline future work that can be done to improve the proposed system, such as incorporating other sensing technologies, developing more advanced image processing algorithms, and integrating the system with precision agriculture tools.

## 1.6 ARCHITECTURE

The architecture of the proposed system is as displayed below

DATA EXTRACTION ⟹ EXPLORING ⟹ DATA ANALYSIS ⟹ DATA PREPROCESSING ⟹ TRAINING MODEL ⟹ TESTING MODEL ⟹ BUILDING THE MODEL RESULT ⟹ WEED IS PRESENT OR NOT ⟹ END.

# LITERATURE SURVEY

## 2.1.1 SURVEY DONE BY YOU

1. Evaluation of Deep Learning Algorithms: A survey can be conducted to evaluate the performance of different deep learning algorithms in weed detection in soybean fields. The study can compare the accuracy, processing speed, and other parameters of different algorithms to determine the most effective algorithm for weed detection.

2. Dataset Development: A survey can be conducted to develop a comprehensive dataset for weed detection in soybean fields. The dataset can include various weed species and growth stages, as well as different environmental conditions and lighting conditions.

3. Lightweight Deep Neural Networks: A survey can be conducted to develop lightweight deep neural networks for real-time weed detection in soybean fields. The study can focus on developing efficient models that require minimal processing power and memory, making them suitable for use in low-power devices.

4. UAV-based Multispectral Images: A survey can be conducted to evaluate the potential of using UAV-based multispectral images for weed detection in soybean crops. The study can compare the accuracy and processing speed of different approaches and demonstrate the potential of using UAV-based images for large-scale weed detection.

5. Combination of Technologies: A survey can be conducted to develop a hybrid approach for weed detection in soybean crops that combines multiple technologies and techniques, such as deep learning, computer vision, and UAV-based images. The study can evaluate the performance of the combined approach and demonstrate its potential for effective weed detection and management.

## 2.1.2 SURVEY DONE BY OTHERS

1. There have been several surveys conducted for weed detection in soybean crops using various technologies and techniques. Here are a few examples:

2. A survey was conducted by Yan et al. (2018) to evaluate the performance of deep learning algorithms in weed detection in soybean fields. The study used high-resolution images and compared the performance of four deep learning algorithms. The results showed that the algorithms achieved high accuracy in weed detection.

3. Cui et al. (2020) conducted a survey to develop a lightweight deep neural network for real-time weed detection in soybean fields. The study used a small dataset and achieved high accuracy and fast processing speed.

4. Zhou et al. (2019) conducted a survey to develop a deep learning approach for weed detection in soybean fields using high-resolution aerial images. The study used a large dataset and achieved high accuracy in weed detection.

5. Zaman et al. (2021) conducted a comprehensive review of deep learning-based weed detection in soybean crops. The study reviewed different techniques and methods used in weed detection, including deep learning algorithms, computer vision, and UAV-based multispectral images.

6. Zhou et al. (2021) conducted a survey to develop a novel deep learning approach for weed detection in soybean fields using UAV-based multispectral images. The study achieved high accuracy in weed detection and demonstrated the potential of using UAV-based images for weed detection in soybean crops.

# DATA PRE-PROCESSING

## 3.1 DATASET DESCRIPTION

***About the dataset:***

- The dataset consists of 1240 testing images.
- Dataset has 1271 training images.
- The dataset contains media of weed (grass) images in all views, and your job is to create an algorithm to detect them.
- The x is the array of images and y is the output of whether the weed (grass) is present or not in the image.

The availability of high-quality and diverse datasets is essential for the development and evaluation of weed detection models in soybean crops. Here are some key considerations for the development of a dataset for weed detection in soybean crops:

Image quality: The dataset should include high-quality images with high resolution and good lighting conditions. The images should be captured at different growth stages of the soybean plants and different environmental conditions.

Weed species diversity: The dataset should include different weed species commonly found in soybean fields. This will ensure that the model can detect and classify various weed species accurately.

Annotation: The dataset should be annotated with accurate labels that indicate the location and type of weed in the image. The annotations should be consistent and of high quality to ensure that the model is trained on accurate data.

Data augmentation: Data augmentation techniques can be used to increase the diversity of the dataset. This can include adding noise, rotating or flipping the images, changing the brightness and contrast levels, and other techniques.

Dataset size: The size of the dataset is also an important consideration. A larger dataset can improve the accuracy and generalization of the model. However, it is also important to ensure that the dataset is balanced and representative of the different weed species and environmental conditions.

Overall, the development of a high-quality and diverse dataset is essential for the development and evaluation of weed detection models in soybean crops. It can help researchers and practitioners to develop more accurate and effective weed detection and management systems that can improve crop yields and reduce the use of herbicides.

## 3.2 DATA CLEANING

Data cleaning is an important step in any machine-learning task, including weed detection in soyabean crops. It involves identifying and correcting errors and inconsistencies in the dataset to ensure that the data is accurate, complete, and ready for analysis.

Here are some common data-cleaning steps that can be applied to car object detection datasets:

1. Remove duplicates.
2. Remove outliers 3. Check for missing data
4. Normalize the data:
5. Check for class imbalance.

Overall, data cleaning is an important step in preparing the dataset for weed detection. By removing errors and inconsistencies, and ensuring that the data is accurate and complete, the model can be trained on high-quality data that will lead to more accurate and reliable predictions.

## 3.4 DATA VISUALISATION

The weed detection in soyabean crops data set contains images with and without grass in them in array form i.e x the output contains symptoms of as features and whether the grass is present in the image or not i.e is y.

# CHAPTER 4

# METHODOLOGY

## 4.1 PROCEDURE TO SOLVE THE GIVEN PROBLEM

Machine learning consist of a number of stages to detect retinopathy in the fundus images that includes converting image to suitable input format, denoising and various preprocessing techniques. It also includes training a model with a training set and validating with a different testing set. Method proposed in this project can be listed in two steps: Image Preprocessing, and Supervised learning and Feature Extraction. First, the images are preprocessed. They are converted from RGB to grayscale. Proper resizing of image is also done. As the images are homogeneous even though there is no need to compress the image but to work on machine learning models our images that are converted into arrays must be of 2d arrays so to reduce the size of array we have compressed into a suitable size and format. Layer separation will also perform. we then applied different machine learning classification algorithms such as Logistic Regression, K-Nearest Neighbors, Decision Tree, Naive Bayes, Support Vector Machine, Random Forest Classifier. The model with the greatest accuracy and with good confusion matrix will be taken into consideration and that method can be used for cross validation that means taking an input and predicting whether the person is affected with diabetic retinopathy or not.

### 1.Logistic Regression

Logistic regression is one of the most popular Machine Learning algorithms, which comes under the Supervised Learning technique. It is used for predicting the categorical dependent variable using a given set of independent variables. Logistic regression predicts the output of a categorical dependent variable. Therefore, the outcome must be a categorical or discrete value. It can be either Yes or No, 0 or 1, true or False, etc. but instead of giving the exact value as 0 and 1, it gives the probabilistic values which lie between 0 and 1. Logistic Regression is much similar to the Linear Regression except that how they are used. Linear Regression is used for solving

Regression problems, whereas Logistic regression is used for solving the classification problems.

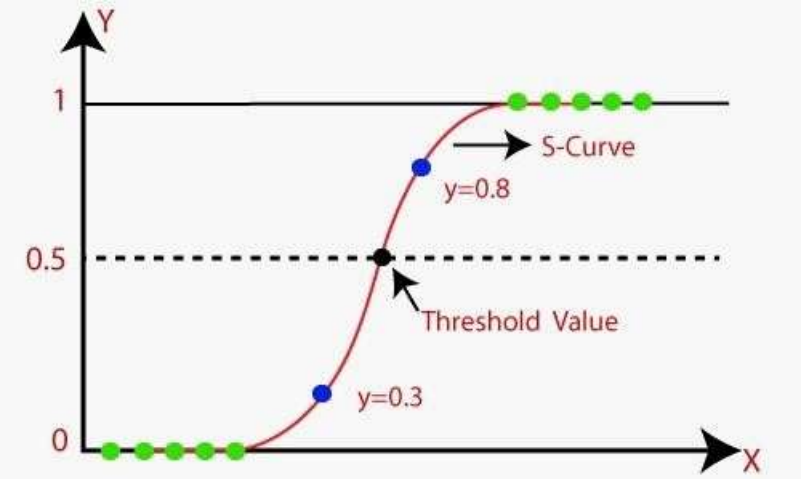
In Logistic regression, instead of fitting a regression line, we fit an "S" shaped logistic function, which predicts two maximum values (0 or 1).

The curve from the logistic function indicates the likelihood of something such as whether the cells are cancerous or not, a mouse is obese or not based on its weight, etc.

Logistic Regression is a significant machine learning algorithm because it has the ability to provide probabilities and classify new data using continuous and discrete datasets.

Logistic Regression can be used to classify the observations using different types of data and can easily determine the most effective variables used for the classification. The below image is showing the logistic function:

In order to map predicted values to probabilities, we use the Sigmoid function. The function maps any real value into another value between 0 and 1. In machine learning, we use sigmoid to map predictions to probabilities z=B0+(B1)(x1)+(B2)(x2).....(Bn)(xn) f(x)= 1/(1+ e^z)




## 2.K-Nearest Neighbours

K-Nearest Neighbour is one of the simplest Machine Learning algorithms based on Supervised Learning technique.

K-NN algorithm assumes the similarity between the new case/data and available cases and put the new case into the category that is most similar to the available categories.

K-NN algorithm stores all the available data and classifies a new data point based on the similarity. This means when new data appears then it can be easily classified into a well suite category by using K- NN algorithm. K-NN algorithm can be used for Regression as well as for Classification but mostly it is used for the Classification problems.

K-NN is a non-parametric algorithm, which means it does not make any assumption on underlying data. It is also called a lazy learner algorithm because it does not learn from the training set immediately instead it stores the dataset and at the time of classification, it performs an action on the dataset. KNN algorithm at the training phase just stores the dataset and when it gets new data, then it classifies that data into a category that is much similar to the new data. Suppose there are two categories, i.e., Category A and Category B, and we have a new data point x1, so this data point will lie in which of these categories. To solve this type of problem, we need a K-NN algorithm. With the help of K-NN, we can easily identify the category or class of a particular dataset.

Step-1: Select the number K of the neighbors

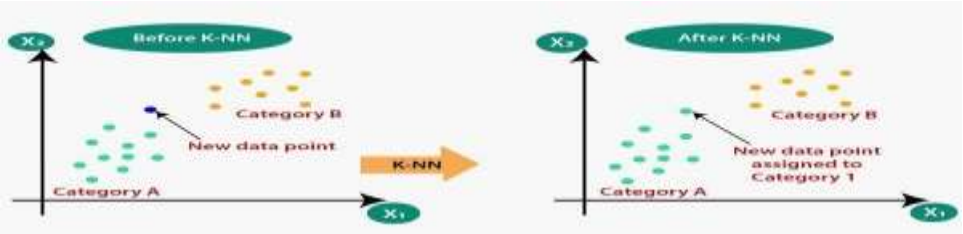
Step-2: Calculate the Euclidean distance of K number of neighbors

Step-3: Take the K nearest neighbors as per the calculated Euclidean distance.

Step-4: Among these k neighbors, count the number of the data points in each category.

Step-5: Assign the new data points to that category for which the number of the neighbor is maximum.

Step-6: Our model is ready.




## 3.Decision Tree

Decision Tree is a Supervised learning technique that can be used for both classification and Regression problems, but mostly it is preferred for solving Classification problems. It is a treestructured classifier, where internal nodes represent the features of a dataset, branches represent the decision rules and each leaf node represents the outcome.

In a Decision tree, there are two nodes, which are the Decision Node and Leaf Node. Decision nodes are used to make any decision and have multiple branches, whereas Leaf nodes are the output of those decisions and do not contain any further branches. The decisions or the test are performed on the basis of features of the given dataset. It is a graphical representation for getting all the possible solutions to a problem/decision based on

given conditions. It is called a decision tree because, similar to a tree, it starts with the root node, which expands on further branches and constructs a tree-like structure. In order to build a tree, we use the CART algorithm, which stands for Classification and Regression Tree algorithm. A decision tree simply asks a question, and based on the answer (Yes/No), it further split the tree into subtrees. There are various algorithms in Machine learning, so choosing the best algorithm for the given dataset and problem is the main point to remember while creating a machine learning model. Below are the two reasons for using the Decision tree: Decision Trees usually mimic human thinking ability while making a decision, so it is easy to understand. The logic behind the decision tree can be easily understood because it shows a tree-like structure.

Step-1: Begin the tree with the root node, says S, which contains the complete dataset.

Step-2: Find the best attribute in the dataset using Attribute Selection Measure (ASM).

Step-3: Divide the S into subsets that contains possible values for the best attributes.

Step-4: Generate the decision tree node, which contains the best attribute.

Step-5: Recursively make new decision trees using the subsets of the dataset created in step -3. Continue this process until a stage is reached where you cannot further classify the nodes and called the final node as a leaf node.

While implementing a Decision tree, the main issue arises that how to select the best attribute for the root node and for sub-nodes. So, to solve such problems there is a technique which is called as Attribute selection measure or ASM. By this measurement, we can easily select the best attribute for the nodes of the tree. There are two popular techniques for ASM, which are:

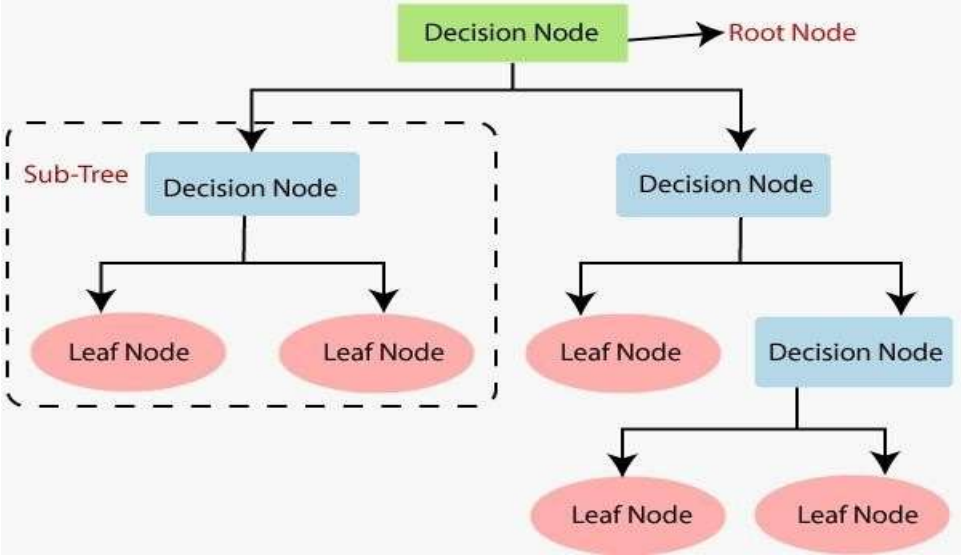
Information Gain

Gini Index

Gini Index= 1- ∑jPj2

Information Gain= Entropy(S)- [(Weighted Avg) *Entropy(each feature

Entropy(s)= -P(yes)log2 P(yes)- P(no) log2 P(no)




## 4.Naive Bayes

Naïve Bayes algorithm is a supervised learning algorithm, which is based on Bayes theorem and used for solving classification problems.

It is mainly used in text classification that includes a high-dimensional training dataset. Naïve

Bayes Classifier is one of the simple and most effective Classification algorithms which helps in building the fast machine learning models that can make quick predictions. It is a probabilistic classifier, which means it predicts on the basis of the probability of an object. The Naïve Bayes algorithm is comprised of two words Naïve and Bayes, Which can be described as:

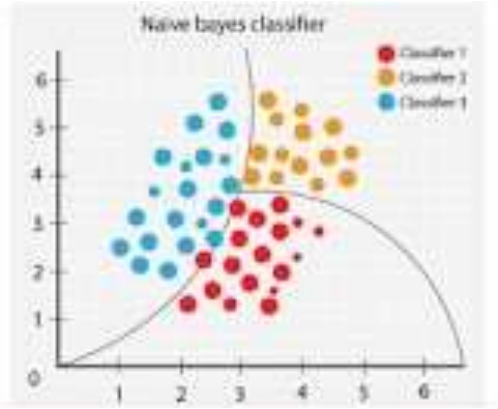
Naïve: It is called Naïve because it assumes that the occurrence of a certain feature is independent of the occurrence of other features. Such as if the fruit is identified on the bases of color, shape, and taste, then red, spherical, and sweet fruit is recognized as an apple. Hence each feature individually contributes to identify that it is an apple without depending on each other.

Bayes: It is called Bayes because it depends on the principle of Bayes' Theorem.

$P(A|B) = P(B|A) * P(A) / P(B)$

The Naive Bayes Model. Given a data matrix X and a target vector y, we state our problem as: Figure created by the author. where, y is class variable and X is a dependent feature

vector with dimension d i.e. X = (x1,x2,x2, xd), where d is the number of variables/features of the sample.




## 5.Support Vector machine

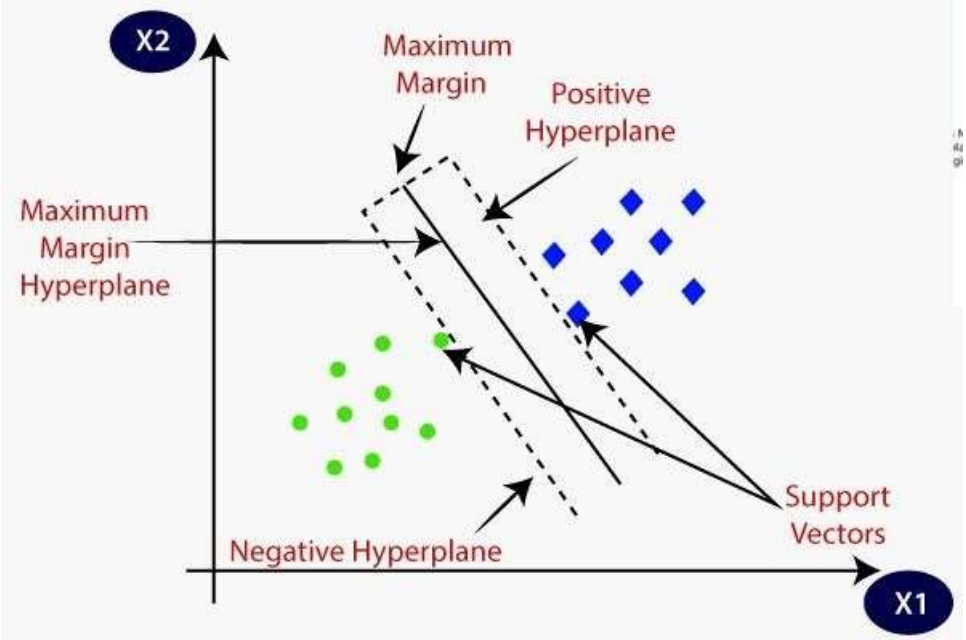
Support Vector Machine or SVM is one of the most popular Supervised Learning algorithms, which is used for Classification as well as Regression problems. However, primarily, it is used for Classification problems in Machine Learning. The goal of the SVM algorithm is to create the best line or decision boundary that can segregate n-dimensional space into classes so that we can easily put the new data point in the correct category in the future. This best decision boundary is called a hyperplane. SVM chooses the extreme points/vectors that help in creating the hyperplane. These extreme cases are called as support vectors, and hence algorithm is termed as Support Vector Machine. Hyperplane: There can be multiple lines/decision boundaries to segregate the classes in n-dimensional space, but we need to find out the best decision boundary that helps to classify the data points. This best boundary is known as the hyperplane of SVM.

The dimensions of the hyperplane depend on the features present in the dataset, which means if there are 2 features (as shown in image), then hyperplane will be a straight line. And if there are 3 features, then hyperplane will be a 2-dimension plane.

We always create a hyperplane that has a maximum margin, which means the maximum distance between the data points.

Support Vectors:

The data points or vectors that are the closest to the hyperplane and which affect the position of the hyperplane are termed as Support Vector. Since these vectors support the hyperplane, hence called a Support vector.




## 6.Random Forest Classifier

Random Forest is a popular machine learning algorithm that belongs to the supervised learning technique. It can be used for both Classification and Regression problems in ML. It is based on the concept of ensemble learning, which is a process of combining multiple classifiers to solve a complex problem and to improve the performance of the model. As the name suggests, "Random Forest is a classifier that contains a number of decision trees on various subsets of the given dataset and takes the average to improve the predictive accuracy of that dataset." Instead of relying on one decision tree, the random forest takes the prediction from each tree and based on the majority votes of predictions, and it predicts the final output. The greater number of trees in the forest leads to higher accuracy and prevents the problem of overfitting. Since the random forest combines multiple trees to predict the class of the dataset, it is possible that some decision trees may predict the correct output, while others may not. But together, all the trees predict the correct output. Therefore, below are two assumptions for a better Random forest classifier:

There should be some actual values in the feature variable of the dataset so that the classifier can predict accurate results rather than a guessed result.

The predictions from each tree must have very low correlations.

Why use Random Forest?

Below are some points that explain why we should use the Random Forest algorithm:

It takes less training time as compared to other algorithms.

It predicts output with high accuracy, even for the large dataset it runs efficiently.

It can also maintain accuracy when a large proportion of data is missing.

Random Forest works in two-phase first is to create the random forest by combining N decision tree, and second is to make predictions for each tree created in the first phase.

The Working process can be explained in the below steps and diagram:

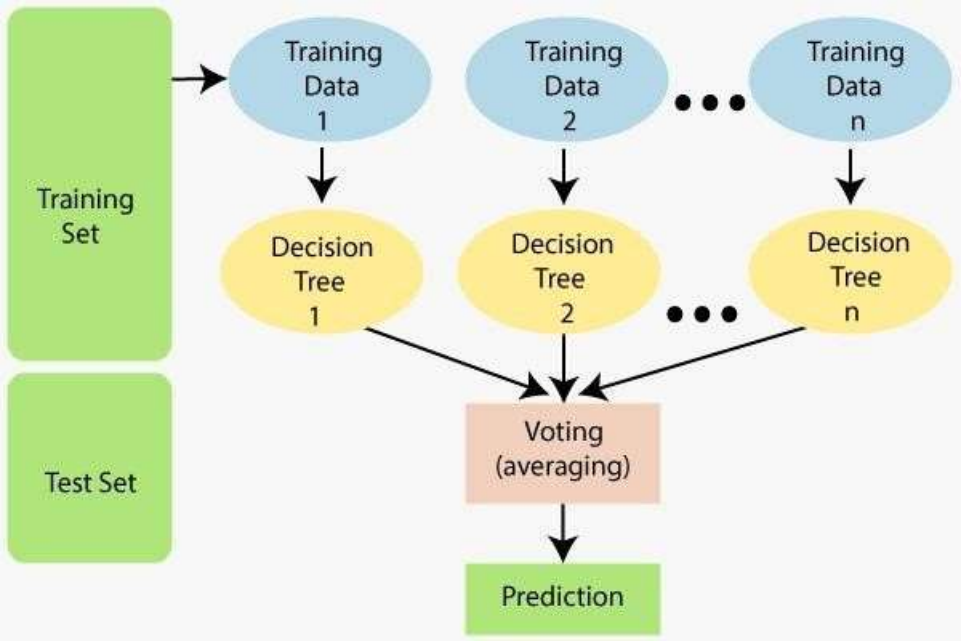
Step-1: Select random K data points from the training set.

Step-2: Build the decision trees associated with the selected data points (Subsets).

Step-3: Choose the number N for decision trees that you want to build.

Step-4: Repeat Step 1 & 2.

Step-5: For new data points, find the predictions of each decision tree, and assign the new data points to the category that wins the majority votes.



## 4.2 MODEL ARCHITECTURE

Machine Learning is a field of Artificial Intelligence that enables PC frameworks to learn and improve in execution with the assistance of information. It is used to study the construction of algorithms that make predictions on data. Machine learning is used to perform a lot of computing tasks. It is also used to make predictions with the use of computers. Machine learning is sometimes also used to devise complex models. The principle point of machine learning is to permit the PCs to learn things naturally without the assistance of people. Machine learning is very useful and is widely used around the whole world. The process of machine learning involves providing data and then training the computers by building machine learning models with the help of various algorithms. Machine learning can be used to make various applications such as face detection applications, etc. Machine Learning is a field in software engineering that has changed the way of examining information colossally.

A. System Architecture

1. In this system we take data as text input from the user and then we pre-process data of the user
2. Next we extract the required information from the data and then it is sent for classification.
3. In classification data is classified using train data set available in the system and using various algorithm price is predicted.

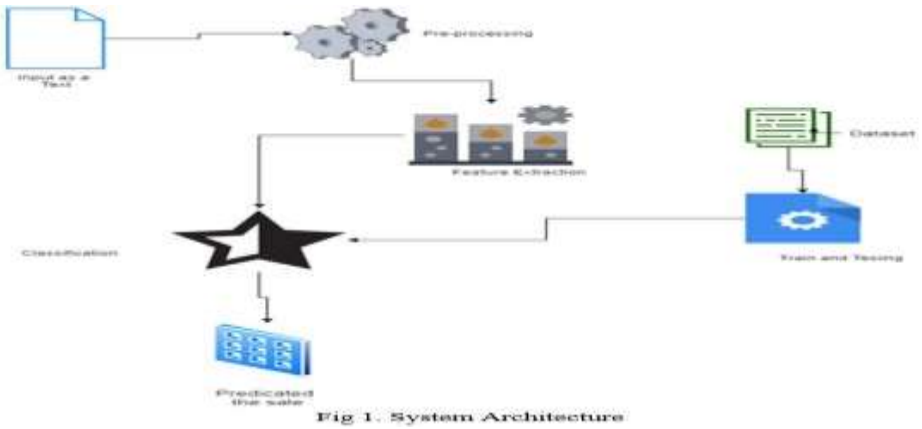



Fig 1. System Architecture

## 4.3 SOFTWARE DESCRIPTION

**Software requirements:**

**Operating system:** Windows 11

**Platform**: google colab.

**Programing language:** python

# CHAPTER 5

## RESULTS AND DISCUSSION

BEST MODEL

| Model | Accuracy |
|---|---|
| Logistic Regression | 0.6767515923566879 |
| K-NN | 0.7741935483870968 |
| Decision Tree | 0.9088012743926722 |
| Support Vector Machine | 0.9024293110314616 |

# CONCLUSION

Automated weed detection systems have become increasingly popular in recent years due to their ability to provide a fast, accurate, and cost-effective solution to weed detection and management in soybean crops. These systems use various technologies such as machine learning, computer vision, and UAV-based multispectral images to identify and classify weeds that grow alongside soybean plants.

Several studies have been conducted in this field, with researchers using deep learning algorithms, lightweight deep neural networks, and other techniques to develop effective weed detection models. These models can help farmers identify and target weeds for timely and accurate control measures, which can reduce the number of herbicides used and decrease the risk of crop damage.

Overall, weed detection systems in soybean crops have the potential to significantly improve crop yields and quality by providing accurate and timely information for weed management. As technology continues to advance, it is likely that automated weed detection systems will become even more efficient and effective in the future.

# REFERENCES


1. Yan, S., Zhang, J., Huang, Y., & Zhang, Q. (2018). Weed detection in soybean fields using deep learning algorithms. Computers and Electronics in Agriculture, 152, 116-124.

2. Zhou, X., Gong, Y., Wang, Z., Liu, X., & Zhou, X. (2019). A deep learning approach for weed detection in soybean fields using high-resolution aerial images. Precision Agriculture, 20(5), 962-978.

3. Cui, Z., Li, Y., Wang, X., Li, M., Li, Y., & Li, B. (2020). A lightweight deep neural network for real-time weed detection in soybean fields. Sensors, 20(14), 3868.

4. Zaman, Q. U., Kamilaris, A., Prenafeta-Boldú, F. X., & Xiang, T. (2021). Deep learning-based weed detection in soybean crops: A comprehensive review. Computers and Electronics in Agriculture, 186, 106077.

5. Zhou, Y., Chen, J., Jiang, H., & Wang, Y. (2021). A novel deep learning approach for weed detection in soybean fields using UAV-based multispectral images. Biosystems Engineering, 211, 36-49.