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ORIGINAL PAPER

SVM-based compliance discrepancies detection using remote sensing for organic farms

Markkandan S[1] · Aditi Sharma[2] · Surendra Pal Singh[3] · Vikas Solanki[4] · Selvakanmani Sethuramalingam[5] · Simar Preet Singh[6]

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Abstract

Organic farming is well-known as a traditional farming method which is responsible in producing the hygienic food product. The organic farm is the integration of agricultural production and system management. Organic farming includes the usage of low pesticides, maintains low nitrate leaching in groundwater as well as surface water, uses animal wastes, and minimizes soil erosion. Crop rotation, natural pest control, and barrier nets are the conventional methods of fertilization techniques. Organic farming makes use of recycling resources comparatively to using chemical fertilizers. A natural compost, animal manure with crop rotation implementation will improve the soil quality. Thus, organic foods are highly hygienic without causing any side effects. A few challenges arise during the implementation of organic farms. These challenges are overcome only via the smart approach and planning and coordination of public and government officials. Organic seeds take a long time to grow, and it is an economically high cost to implement this type of farming. Smart transport and supply of organic products to any location is a bit difficult. The proper selection of seed and selection of land with the suitable climate and soil texture that has to be verified for cultivation is the restrains of organic agriculture. Soil moisture content and sufficient water for the crop are attained through the usage of remote sensing in agricultural farms. The food crisis can be managed via the adaptation of remote sensing. The sensor collects information about the soil, water supply, temperature, and other environmental factors to the control unit. Initially, the infected plant with leaves will be isolated as single image as leaf, and each leaf would be diagnosed with various kernel functions including Cauchy, Invmult, and Laplacian kernel. The proposed system uses image processing to capture the images, and the remote sensing sensor generates the information to the Support Vector Machine which classifies the infected plant or part of the plant from the healthy plant based on the features extracted. The proposed Support Vector Machine (SVM) used a remote sensing technique in detecting the compliance discrepancies in an organic farm.

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Responsible Editor: Hoshang Kolivand

✉ Markkandan S
markkandan@gmail.com

Aditi Sharma
aditi11121986@gmail.com

Surendra Pal Singh
surendra.geomatics@gmail.com

Vikas Solanki
solanki.vikas1@gmail.com

Selvakanmani Sethuramalingam
sskanmani6@yahoo.com

Simar Preet Singh
dr.simarpreetsingh@gmail.com

1 Department of ECE, SRM TRP Engineering College, Trichy, Irungalur, India

2 Department of Computer Science & Engineering, Quantum University, Roorkee, India

3 Surveying Engineering Department, Wollega University, Nekemte City, Ethiopia

4 Chitkara University Institute of Engineering and Technology, Chitkara University, Punjab, India

5 Department of Computer Science and Engineering, Velammal Institute of Technology, Chennai, India

6 GNA University, Phagwara, India

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Introduction

In today's world, organic farming is showing drastic growth in the developing society. The main reason for the development of organic farms due to the severe crisis for food in the growing population, and hence, it is necessary to encourage farm cultivation to increase the food production rate for a low cost. Most of the agricultural lands are utilized for the development of organic fruits and vegetables (Lockeretz 2007). Many developed and developing countries implemented these types of organic farms to overcome the consequence due to the food crisis (Meemken and Qaim 2018; Reganold and Wachter 2016; Willer et al. 2020). The social and economic development of the country depends on agricultural production. The land resources have to be preserved for the vegetation purpose as it may result in food scarcity (Awokuse and Xie 2015; Peterson et al. 2017). The modern farming method uses chemical fertilizers, synthetic pesticides, herbicides, germicides, and genetically engineered seeds to increase the production rate mainly to overcome food scarcity. This revolutionary farming method affects humans and animals consuming this farming food and even causes damage to the natural resources. Due to the adaptation of this farming method, children are born with the disability due to the consumption of chemical foods. Organic farming is costlier, and therefore the farmers are economically unsupported to cultivate organic foods. Organic food is the most preferred product in the market. Many people are switching the organic food to improve their immune systems. The demand for organic food is flourishing. Instead of artificial fertilizers and pesticides, conventional fertilization techniques are adopted in organic farming.

An adequate crop yield is affected due to crop diseases. The crop disease affects the livelihood of the framers whose income is dependent on healthy crop production with a high-quality range (Bharwad and Dangarwala 2015). In organic agricultural farms, image processing techniques are utilized to increase the cultivation rate. Precise detection of crop disease due to the various factors is diagnosed to prevent the plant crop from injury. Farmers can take some precautions if they are detecting compliance at an earlier stage. The possibility of ignorance of the farmers towards the crops is high, and hence, a separate innovative technique is preferred to monitor the crop yield in organic farms (Mokhtar et al. 2015). The information regarding the crop is transformed to the farmer via superior techniques involved in an agricultural field. The implementation of innovative technologies even in the agricultural field reduces the loss with the corresponding increase in the production rate. Thus, there is no separate specific monitoring of the agricultural field by the farmers and agricultural officers (Chen et al. 2012). Weather prediction is more important for efficient agriculture since the atmospheric content is more essential for the growth of crops in organic farms. Drought detection, agriculture, production, pollution dispersal, and climatic changes are to be regularly notified (Pal et al. 2003). Predictions of atmospheric temperature, rainfall, wind speed, and meteorological pollution are a more challenging task, and hence, the different methodologies, namely, linear regression, autoregression, radial basis function networks, and multi-layer perception techniques are used for the weather prediction (Pal et al. 2003; Jae 2005; Mohandes and Halawani 2004; Yu 2006; Osowski and Garanty 2007; [illegible] 2005).

Remote sensing is capable of gathering information about an object without having direct contact with that object. The electromagnetic radiation present in the remote sensing that travels at the speed of light at different wavelengths is acting as a carrier. Visible light (VIS) extends through the near (NIR), thermal infrared (TIR), and shortwave infrared (SWIR), and microwave bands are the various types of wavelength used in remote sensing. Remote sensing is used in organic farms to identify the consequences before harming the crops. Thus, remote sensing is considered to be an alarming technique preventing the crops from great impact. The crop production also increased with the support of remote sensing data. The environmental impact is also reduced by using remote sensing in organic farms. Nutrition needed for plants, a nutrient needed for soil, water demand, controlling of weed, and forecasting crop yield, is identified via the usage of remote sensing data (Jackson 1986). The remote sensing technique includes the sensor connected with the platforms, namely, an aircraft, satellite, and a UAV/UGV (Roy et al. 2002). In the agricultural field, soil moisture content, temperature, leaf nitrogen content, crop phenology, inclination of leaf, plant density, and crop growth cycle are estimated using remote sensing (Nock et al. 2016).

Support Vector Machines (SVMs) are used in solving many contemporaneous consequences using a threshold value. The conventional regression type of support vector machines is used earlier to solve the consequences with regard to regression. The algorithmic approach is developed into linear and non-linear models. The linear model includes the slack variables which cause the noise in the data. The supportive evaluation and diagnose from various kernel functions in support vector machine used techniques like N-cross and grid search during testing phase. The space input is indoctrinated into the larger dimension in a non-linear model (González Costa et al. 2017). Thus, SVM is provided with the supervised learning algorithm, and this machine learning approach is considered to be the best predictor with a high degree of accuracy (Zhang and Gao 2018).

Literature survey

Agriculture is essentially important for the livelihood of all living organisms in this world. The crops in the organic farms are affected by various diseases and many other environmental conditions which may lead to food crisis. Human involvement is unable to predict the causal factor for the low production rate in the farms. Therefore, to overcome these issues, various technologies are used in the agricultural field in identifying the error. Image processing is the best approach that can predict the cause factor deploying the plant at a high precise rate (Lin et al. n.d.).

Artificial Neural Network (ANN) is employed in identifying the causative factors which cause the disease in plant crops. In this approach, the image of the plant is converted from RGB to gray. Template histogram and color features are obtained in this model. In this research, the mean and standard deviation are included in the color characteristic features. Depending on these features, the feed-back propagation neural network of the disease affecting the banana plant is identified (Tigadi and Sharma n.d.). The most essential role of the proposed system model is to segregate the diseased plant or part of the plant from the healthy plant or a healthy part of the plant. The removal of the affected region can be done through the segmentation methodologies, namely, clustering.

Otsu threshold along with the Support Vector Machine (SVM) is enhanced to identify the diseased leaf from a healthy plant. In this proposed system, initially pre-processing is carried out modifying the color contrasting followed by which RGB image is transformed into YCbCr. The affected region is eliminated from the entire plant using the Otsu threshold. The segmented image contains a Gabor filter mainly to extract the feature required. Support Vector Machine (SVM) categorizes by considering the extracted feature as input (Kadu et al. n.d.).

The color analysis was performed to identify the disease-affected leaf of betel vine. The inessential information gathered during the pre-processing process is removed by performing the cropping process. The main purpose of the color feature in the analysis process is to differentiate the rotten leaf from the healthy part. Followed by this, the image is transformed into various color spaces, namely, RGB, HSV, and YCbCr. The result showed that the HSV was the best in comparison with others in differentiating the rotten part of the plant. The rotten part is transformed into the binary image which is identified using the white pixel estimation (Deya et al. n.d.).

Tomato is required all over the world, and it is considered to be the day neural plant (Tm et al. 2018). In any seasonal climatic changes, the tomato plant can be cultivated. The nutrients and fertilizers are more essential for the growth of the crop. Blight, late blight, bacteria, viruses, and septoria leaf spots are the disease affecting the tomato plants (Sabrol and Satish 2016). Maize cultivation requires a large land area for the cultivation of crops. The sunlight is required for the entire day for the healthy growth of crops, and it may be cultivated in different patterns. After the minimum of a 1-month time gap, the changes in the crop can be notified, and now it would be edible for eating. Thus, the Support Vector Machine (SVM) and Artificial Neural Network (ANN) algorithm were proposed to improve the prediction precise rate and performance efficiency. The training set values are cross-evaluated in a desktop learning to estimate the performance efficiency of the proposed system. In the SVM, photo courtesy was to identify the plant disease (Arlot and Celisse 2010).

An image processing system was developed to detect plant disease. Initially, the obtained images enter the pre-processing stage followed by which the image segmentation was achieved. The features were extracted from the image captured which was more essential for the detection and classification of diseased plants. The color co-occurrence model was included in the proposed system. Featured map, back propagation algorithm, Support Vector Machine (SVM), and Artificial Neural Networks (ANN) methodologies were used to classify the plant disease. Among the abovementioned techniques, image processing techniques were more effective in determining and classifying plant disease (Sachin and Khirade 2015).

Deep learning image-based system model was enhanced to identify the plant disease. The proposed system included the analysis of the training and testing phase. In the training phase, 150–170 images of the mulberry plant were examined. The acquired dataset of 20–30 images was involved in the testing phase. Through the analysis, a diseased leaf from the normal leaf of the plant was distinguished. The healthy mulberry plant was further classified into red and white mulberry. The aim of the proposed deep convolutional neural network architecture was to distinguish the crop species and to predict the plant disease (Sharada Prasanna Mohanty 2018).

A cloud-based cultivation management system was developed to support farmers in examining their agricultural farms from anywhere using the dataset. The sensors, devices, and ICs for data transmission inbuilt in the hardware module of the proposed monitoring system were placed in the farm field. The cloud was used as the software source with a smartphone as the remote control. The proposed system would help in determining the moisture content in the soil as voltage signals with the predefined threshold value (Rakshak and Deshpande 2017).

System model

Worldwidely, most percentages of the population are health conscious, and hence, the demand for organic products is growing drastically. Agricultural plants are usually affected by diseases, namely, bacteria, fungi, viruses, and other environmental factors. Detection of the compliance discrepancies can be achieved through the implementation of a Support Vector Machine (SVM). The quality of the organic plants only can be improved through the development of a computer-based system. This computerized monitoring system helps the farmers in detecting the discrepancies in the plants. Remote sensing is used to identify the plant disease and factor which is responsible in affecting the crop production. Factor such as temperature, change in soil texture, water imbalance, and disease-causing are the ill effects encountered as the compliance discrepancies.

The proposed system framework includes the control unit, data acquisition, and processing units. Temperature, humidity, and moisture are notified and recorded using the sensors to support the favorable growth of the crop plants.

The process of remote sensing includes energy from sunlight source to object like organic farm and subsequent reflection emitted energy transmission from the land to the sensor is depicted in Fig. 1. The recorded transmission is passed to the ground downlink and processing of data transferred into digital copy. Obtaining the digital copy data, it has been analyzed for better improvement in crops agriculture organic farm. The image processing algorithmic approach can detect the infection or disease caused to plant crops. The control unit stores all the collected informational data, and hence, the difference that arises among the data is noticed. If there is any significant infection or damage to the plant is detected in the data, it will be notified to the farmer. The installation of a camera in an organic farm enables the capturing of images at some time space to continuously monitor the infection or diseases.

The image processing technique was able to notify some of the plant diseases such as leaf scalds disease, red striped disease, and mosaic disease. The proposed system model is shown in Figure 2. The water balance, soil texture, climatic condition, temperature, humidity, and moisture content have to be monitored continuously. To analyze these factors, remote sensing is used which is capable of monitoring and providing the object information without any direct contact. Capturing plant crops and acquisition data from the sensors is considered to be the primary component in detecting compliance discrepancies. A temperature sensor is one of the most important factors considered for the essential growth of the plant crops organic farms. Photosynthesis at the ideal temperature improves the respiration rate of the plants for healthy growth. Depending on the humidity content, the suitable plant crop has to be cultivated with the required water supply for fruition. For an effective water management system, the moisture content in the soil has to be determined using sensors. In organic farms, the irrigation system is properly managed mainly with the support of moisture sensors present in the soil. The information obtained from the sensors morally helps the farmer in detecting the compliance and taking preventive action to increase productivity and quality of the crop. Dihydrotestosterone (DHT) sensor is used in the proposed system architecture that is capable of estimating both the temperature and humidity with the support of two thermistor functional blocks. An analog to digital converter is embedded in the sensors to show the reading to the farmers to take some remedial action.

The image processing algorithm is used to detect the compliance discrepancies in the organic farm. In this process, the images are driven in grayscale. The morphological operation of the K-mean clustering help separates the affected region from the healthy part of the crop. Support Vector Machine (SVM) classifies the infected part using the features extracted and identifies the causative factor which leads to the rotten of

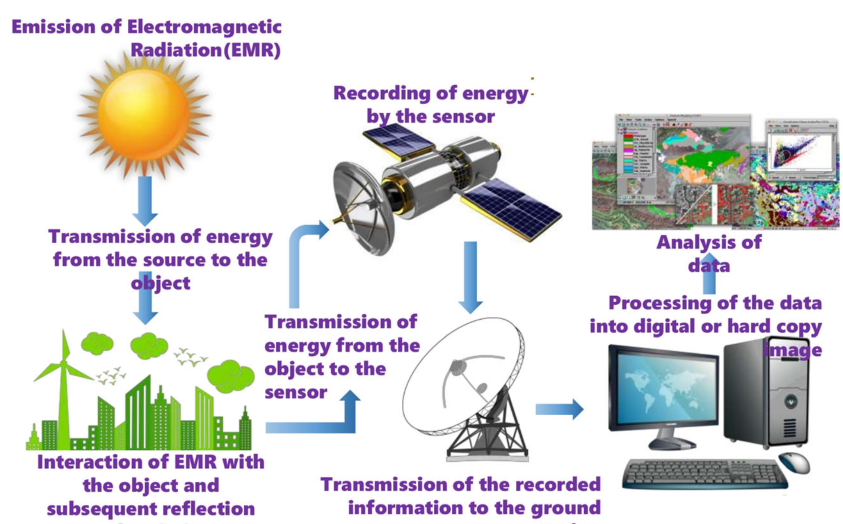

Fig. 1 Remote sensing process.

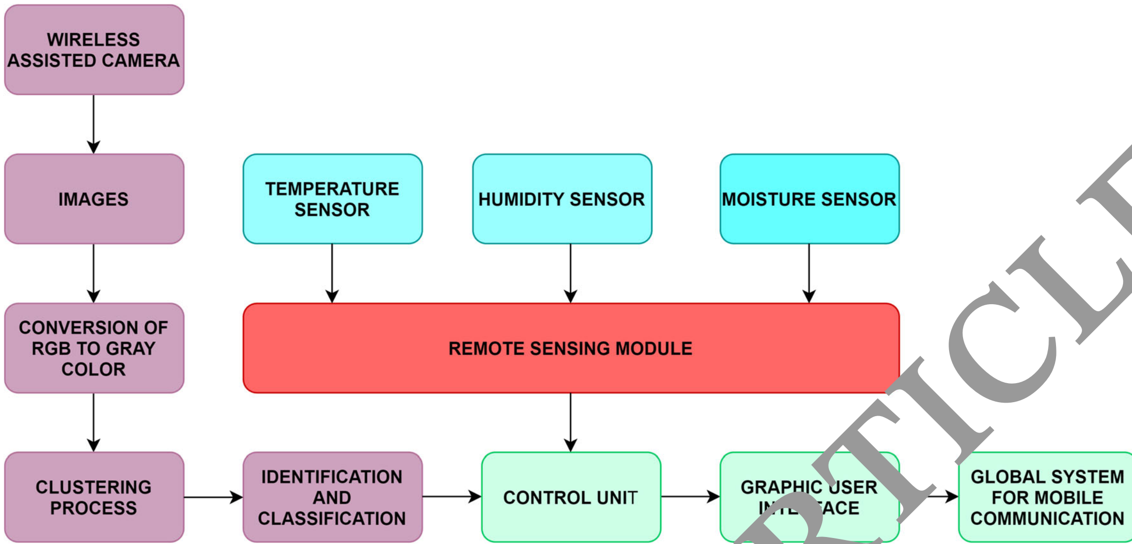

Fig. 2 The proposed system model.

plant part. The Support Vector Machine (SVM)-based compliance discrepancies detection includes the training process initially. The digital camera is involved in this process to capture the plant crops. This image then further undergoes the pre-processing technique. The feature extraction role is gathering the essential features where these features are sent to the training section using the Support Vector Machine algorithm. After completing the training phase, the features provide information on whether it is a rotten or healthy plant crop via SVM.

An unsupervised clustering algorithm, K-mean, is utilized to classify the causative factors affecting the plant through image classification. This algorithmic approach includes more informational data specifically to identify the affected crops in organic farms. Features, namely, color and shape change over, are considered the basis for identifying the faulty region. Finally, the healthy and infected region of the crop is segregated and removed through the morphological operational function. The infected regions are predicted using operation dilation performance and erosion function. The infected part is shown separately via the dilation operation. The filter is used to remove the unwanted noise to improve the quality of the segregation process to get a fine output.

$$\text{Perimeter} = \sum\left[A_{EDGES},\ B_{EDGES},\ C_{EDGES},\ D_{EDGES}\right] \quad (1)$$

Here, A_{EDGES} is the top corner of the perimeter edge, B_{EDGES} is the left corner of the perimeter edge, C_{EDGES} is the bottom corner of the perimeter edge, and D_{EDGES} is the right corner of the perimeter edge. After the refinement process, the Support Vector Machine (SVM) classifies the clustered data.

$(x_1, y_1), (x_2, y_2), \ldots, (x_n, y_n)$ is the representation of training set images. Here, x_1 is considered an input, y_1 is class +1, and y_2 is class −1. Thus, the training images are expressed as follows,

$$x_n \varepsilon R^d \quad (2)$$

$$y_i\ \varepsilon\ (-1, +1); i = 1, 2 \quad (3)$$

Support Vector Machine (SVM) develops a hyperplane using the kernel function (K). The hyperplane classifies the images based on the clustering data such as color and shape denoted as follows,

$$w{\bullet}x + b = 0 \quad (4)$$

Here, the normal to hyperplane is denoted as "w," and the perpendicular distance between hyperplane and origin is denoted as "b." The infected plants come under the class +1, and the healthy plants come under class −1 as shown in the equations below.

$$w{\bullet}x_i + b \geq 1 \quad (5)$$

$$w{\bullet}x_i + b \leq 1 \quad (6)$$

Arduino UNO is used as a control unit. A simplified form of task and execution of code is attained in the Arduino UNO. The remote sensing sensor tracked informational data is provided as an input to the control unit to identify the compliance discrepancies. The Support Vector Machine (SVM) classification is achieved through the wireless remote sensing module. For the continuous access and detection of discrepancies, compliance is possible via the Wi-Fi network. The control unit transmits the information to the farmer's mobile communication source. With the support of the GSM module, the corresponding preventive action for compliance is sent to the farmer. The value of temperature, humidity, and moisture value are obtained from the user interface display graphs to monitor the infection with the support of image processing and SVM classification. The sensor depicting the abnormalities in the plants classifies the output based on the extracted features. The proposed SVM-based compliance discrepancies detection using remote sensing is intended to help the farmers in organic farms increase their production rate and to improve the quality of food.

The proposed methodology includes the data collection, image pre-processing, image cropping, resizing images, fuzzy histogram equalization, features extraction, image segmentation, and classification phases are shown in Fig. 3. As there is less possibility for the continuous monitoring of the agricultural farms, the digital camera with high resolution is placed to capture the images of the plant. The picture pattern is in RGB form (red, green, and blue). These photographs help the farmers in encountering the bacterial spot, mosaic virus, northern blight, rust, etc.

In the image pre-processing, a separate directory is created to hold the various images dataset. The acquired images are stored in the computer system. This image dataset contains a minimum level of noise. This process helps to remove the historical past noise and controls the unwanted distortion. Due to the improper placing of the camera, variation in light source and distortion in the captured images cause discrepancies in plant images. To predict the discrepancies in high precision range, the obtained RGB images have to be

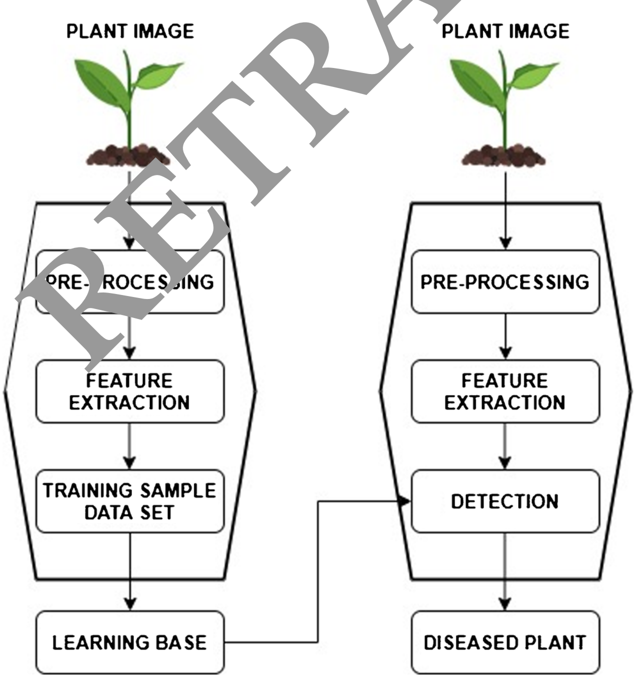

Fig. 3 Architectural system for plant disease prediction.

converted into grayscale images. The quality of the images is improved using Fuzzy Histogram Equalization (FHE) and resized to enter into the training phase. In this stage, the clear appearance of the images is provided which is more important for both the feature extraction and segmentation process. For evaluation of performance in system, cross validation is a common method to deal with various sets of machine learning algorithms. Classification on several kernel functions are trained for compatibility to obtain better simulation results.

As shown in Fig. 4. The images obtained reflect the information about the injured region of the plant. The images are stored in the CPU to identify the discrepancies in an organic farm. To obtain the accurate detection of the discrepancies, the images are cropped. The Matlab function is used to crop the plant image. After cropping, the image is resized to the fixed size. This will be the standard size for all the images as the precise rate of the feature extraction process is not to be affected. Fuzzy Histogram Equalization is initially computed to manage the approximation of gray level value. Based on the image median value, a fuzzy histogram is categorized into two sub-histograms, and later these are equalized to maintain the brightness of images. Using cross validation scheme within testing set, grid search approach validates SVM classifier multiple times. At the end of every kernel function, best validation results are selected.

The organic farming with remote sensing and SVM algorithm permits the classification of two types in earlier of twenty-first century which accomplish data with Landsat and Rapid eye process.

Feature extraction is the process of obtaining the features from the captured images. The images include several pieces of information in which the most essential features involved in the classification process are extracted in this process. Texture, color, shape, and size are few features that help the farmer in distinguishing the rotten part from the healthy crop. Texture and color are found to be more important, but the shape is not much important as the growth in discrepancies is reflecting instantly in the shape of the crop. A supervised computing device learning Support Vector Machine (SVM) algorithm segregates the discrepancies using remote sensing in organic farms and accuracy is measured over days as shown in Fig. 5.

Result and discussion

Based on the statistical learning theory, the Support Vector Machine algorithm is proposed. The optimal hyperplane is developed in a new space via the non-linear mapping function. The non-linear mapping function in SVM maps the inaugural data with the high dimensional feature space. Classification and regression of the extracted features are applicable in Support Vector Machine (SVM). During the classification

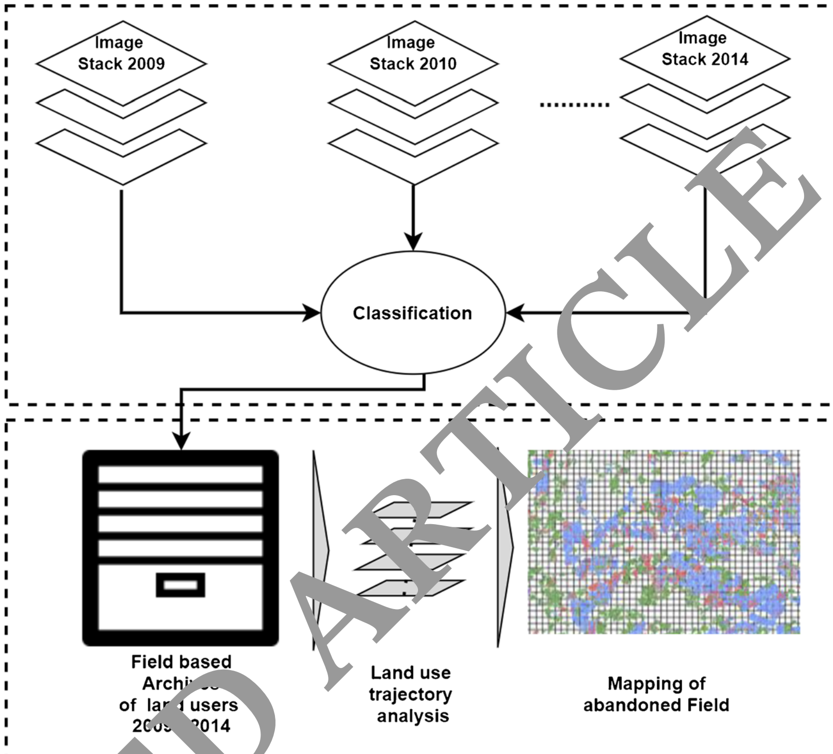

Fig. 4 Mapping analysis of archived field

process, an optimal hyperplane in SVM segregates the data into two different classes. In the case of regression, the hyperplane connects all the possible points which are close to each other. The temperature of the agricultural farm can be predicted using the regression in SVM. This regression scheme varies from the conventional regression technique, and it includes only Structural Risk Minimization (SRM). This support vector regression technique is capable of minimizing the generalized error. This feature improves the performance of the proposed system in detecting compliance discrepancies. Depending on the input dataset, regression estimates the corresponding features. The estimating function of the support vector regression is expressed as follows,

$$f(x) = (w.\phi(x)) + b \tag{7}$$

Here, $\phi(x)$ is the feature space of the non-linear function. The non-linear regression compliance can be obtained by reducing the regularized risk function.

$$R(C) = \frac{1}{2}\|W\|^2 + C\frac{1}{N}\sum_{i=1}^{N} L_{\in}(d_i, y_i) \tag{8}$$

$$\text{where } L_{\in}(d, y) = \begin{Bmatrix} |d-y|-\in & |d-y|\geq\in \\ 0 & \text{others} \end{Bmatrix} \tag{9}$$

The atmospheric temperature is more essential for crop growth, and hence, it is continuously monitored using the support vector regression. Thus, the Support Vector

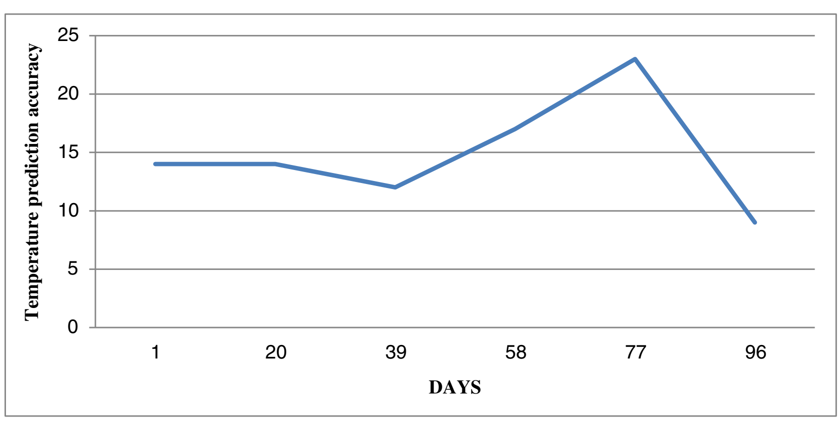

Fig. 5 Performance of Support Vector Machine (SVM).

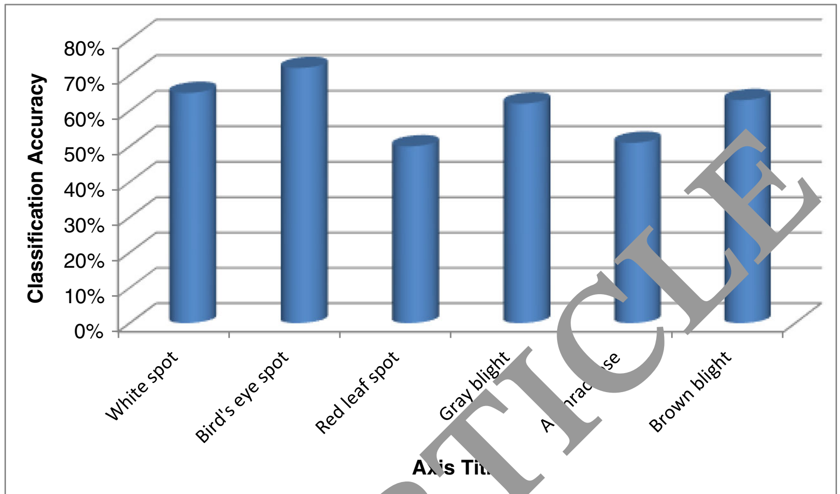

Fig. 6 Classification of a diseased plant using SVM.

Machine (SVM) measures the temperature of the environment effectively in comparison with other network models.

The machine learning approach of identifying the pattern includes the training and testing phase. The proposed system estimated the system accuracy using the training samples. The sample datasets are divided into training and testing sample datasets. A major percentage of datasets are involved in the training phase, whereas the minimum percentage of datasets is involved in the testing phase. The confusion matrix is used to examine the accuracy of the samples. Accuracy (AC) is defined as the ratio of corrected prediction to the addition of corrected prediction (CP) and false prediction (FP).

$$AC = \frac{CP}{(CP + FP)} \tag{10}$$

The accuracy in detecting the compliance discrepancies increases with the increased number of data samples in the training phase. A supervised computing device learning Support Vector Machine (SVM) algorithm is more suitable for the classification and regression challenges. SVM includes the linear system in which the extracted features are available. Depending on the extracted features, the SVM classifies the obtained images into various categories.

Figure 6 shows the various plant diseases and their corresponding percentage rate with the support of Support Vector Machine. The proposed system classifies the diseased plant from the normal plant using SVM in organic farms.

In Table 1, seedling plant growth classified into conifer with height less than 7m and deciduous which implies that growth of plant height lies between range 7 and 9m was described. Further advanced growth was classified into younger growth in height range less than 1.3 m and advanced growth in height range more than 9m.

Figure 7 shows the various kernel functions cross validation scheme and their corresponding percentage rate with the support of Support Vector Machine. The proposed system classifies the diseased plant from the normal plant using SVM in organic farms.

Figure 8 shows the various kernel functions for medium scale cross validation scheme and their corresponding percentage rate with the support of Support Vector Machine. The proposed system classifies the diseased plant from the normal plant using SVM in organic farms.

Figure 9 shows that tending accuracy varies in observation of production of seeds accuracy in fields. Tending and not tending imply about slightly distributed field value between 1 and 3.

Conclusion

In this paper, the Support Vector Machine (SVM) is utilized to distinguish the discrepancies compliance using remote sensing in organic farms. The factors such as water supply, soil texture, atmospheric temperature, climate change, and other environmental factors are estimated using the remote sensing sensors in the proposed system model. The obtained informational datasets are stored in the computer software sent to the

Table 1. Analysis of seedling plant tending

Seedling plants	Conifer	Deciduous	Young growth	Advanced stable growth
Height of plants	Range less than 7m	Range lies between 7 and 9m	Less than 1.3m	More than 9m

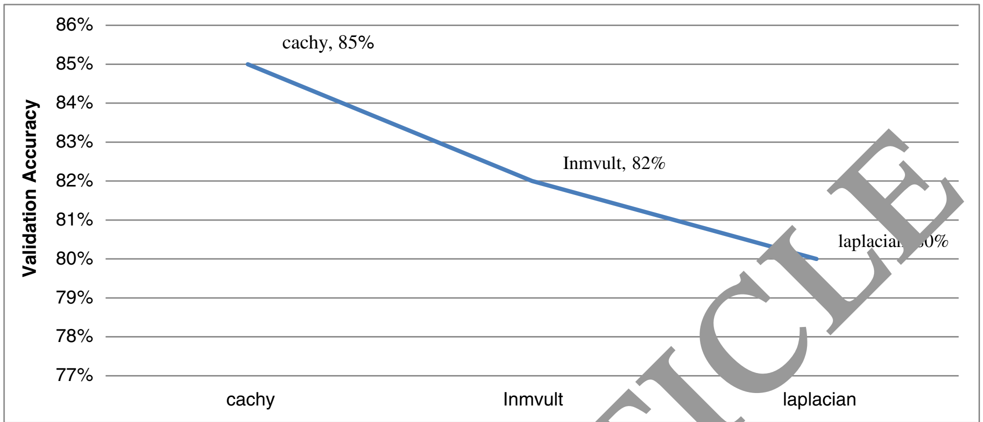

Fig. 7 Big scale cross validation scheme accuracy

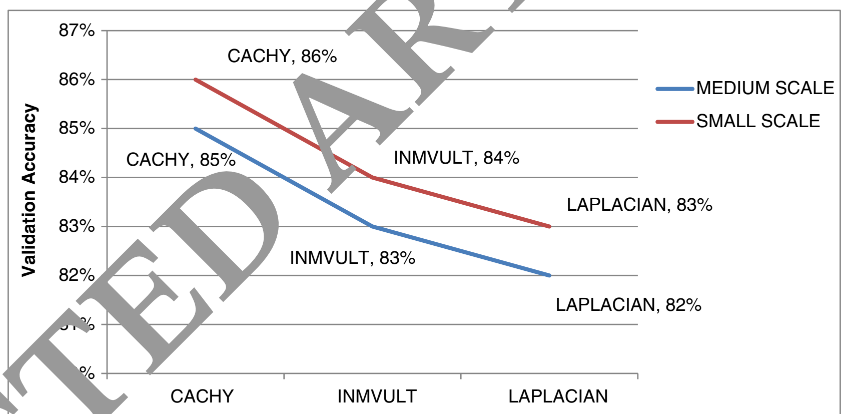

Fig. 8 Medium scale cross validation scheme accuracy

Support Vector Machine (SVM) to predict the status of crops in organic farms. SVM-based compliance discrepancies detection system is enhanced with the motive to help the farmers to increase the production rate and to prevent huge loss. This might also improve the quality of organic food. The systematic communication from the sensors is sent to the user interface where the farmer receives the information about the agricultural farm using the Google system for mobile communication module. Humidity and moisture content in the soil can be maintained with the proposed system model. This

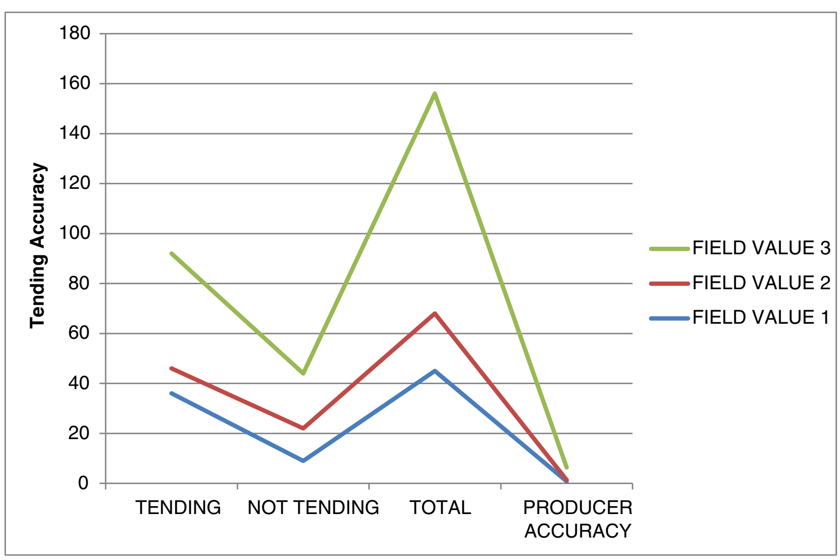

Fig. 9 Various tending accuracy of seedling plants in fields.

method of image processing provides the opportunity for the farmers to take preventive action to save their cultivated crops. Thus, the proposed Support Vector Machine (SVM) using remote sensing in organic farms detects the compliance discrepancies.

Declarations

Conflict of interest The authors declare that they have no conflict of interest.

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