NEMATODE DETECTION SERVICE WEB SERVICES FOR THE NEMATODE DETECTION MODEL BASED ON THE MULTI-TEMPORAL DATA OF COTTON

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Abstract

The reniform nematode *Rotylenchulus reniformis* is a nematode species affecting cotton production and is rapidly spreading across the southeastern United States. An effective management tool is the application of nematicides using variable rate technology. This requires knowledge of the intra-field variability of the nematode population, which depends on the collection of soil samples and analyzing them in the laboratory. This process may be economically prohibitive. Hence estimating the nematode infestation using remote sensing and machine learning techniques which are both cost and time effective is the motivation for this study. In this research, the concept of multi-temporal remote sensing has been implemented to design a robust and generalized nematode detection regression model. Finally, a user friendly web-service is created which is gives trustworthy results for the given input data and thereby reducing the nematode infestation in the crop and their expenses on nematicides.

Introduction

Cotton is an important cash crop in 16 states in the US including Mississippi. An annual turnover of 18.3 million bales was recorded in the year 2010, of which 4% was from Mississippi. With present global economic conditions severe economic pressures are placed on cotton producers to decrease costs and increase yields. The productivity of the cotton crop is often affected by many factors including plant-parasitic nematodes. The reniform nematode, *Rotylenchulus* is a species which is rapidly spreading throughout the southeastern United States. The concentration of the reniform nematodes is highest in Alabama, Louisiana, and Mississippi incurring an economic loss of over $128 million dollars in these three states alone. The use of nematicides is still a major management tactic. Nematicides applied at site specific rates are an economic management tool. This requires the intra-field nematode numbers present in the field depended on collecting numerous soil samples and laboratory analysis. Remote sensing instruments facilitate the collection of a target's (cotton crop) reflected energy and provides insight into the health of the plant. Interpretation of the radiometric information gathered on the vegetation helps us determine nematode numbers without collecting soil samples. The objective of this study was to create a user friendly web-service which is globally available to the farmers providing results for the input data and thereby helping them reduce nematode infestations by site specific nematicide applications and increase economic yields.

Materials and Methods

A machine learning based algorithm is developed which exploits the available multi-temporal hyper-spectral data of the cotton crop and derives a relationship between the biophysical variables of the plant and the corresponding amount of nematode infestation (fig 1). The algorithm exploits the usage of jenny software for the purpose of test case reduction; a radiative canopy reflectance model PROSAIL provides an analysis of the reflectance from the vegetation based on the interaction of the solar radiation and the canopy. Use of feature extraction techniques and feature subset selection allowed the derivation of a more heterogeneous feature space to design a generalized regression model. A combination of the Kernel PCA feature extraction technique and support vector machine regression is used in deriving a robust model. A user friendly web portal is developed in Java using Google Web

Toolkit, which allows the users to interact with the Nematode detection model. A Nematode detection service is developed using the Service Oriented Architecture (SOA) which performs the same steps involved in the proposed methodology and displays the result on a visually appealing Google Map.

The proposed methodology is implemented (Fig. 1) and the results were analyzed using standard metrics, RMSE and correlation coefficient. A 10-fold cross validation correlation coefficient of 0.8442 is obtained for the nematode detection model, which is a significant achievement. The 2-D and 3-D visualizations developed emphasize the importance of each stage of the algorithm.

Results and Discussion

The web portal runs the nematode detection service and it provides a user friendly environment. The user uploads the required data and runs the models. The web portal returns the results on a visually appealing Google Map which makes the analysis easy for the user.

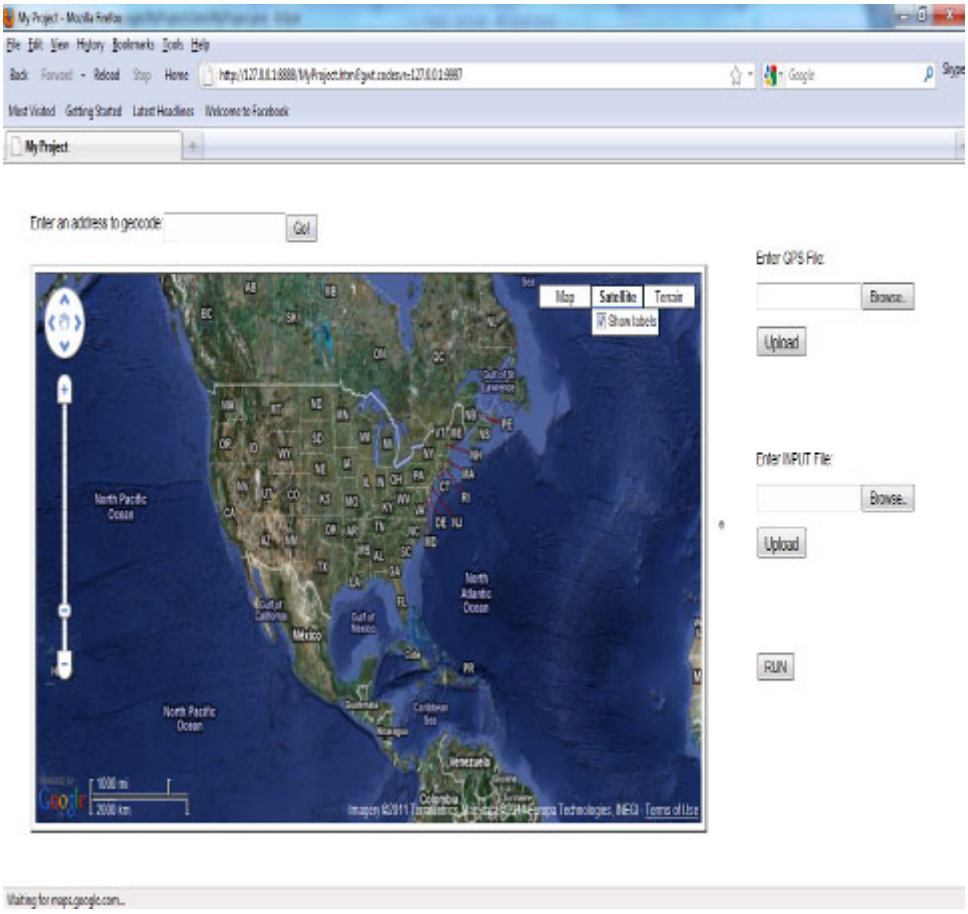

Figure 2. Interactive web portal

The Google Map functions implemented in this web application include the “mapoverview” and “geocoding”. The overview map generally covers a larger area than the main map. The part of the map displayed in the main map is placed within a small rectangle inside the overview map. The functionality of mapoverview control implemented in this web page provides an easy navigation for the user on the Google Map.

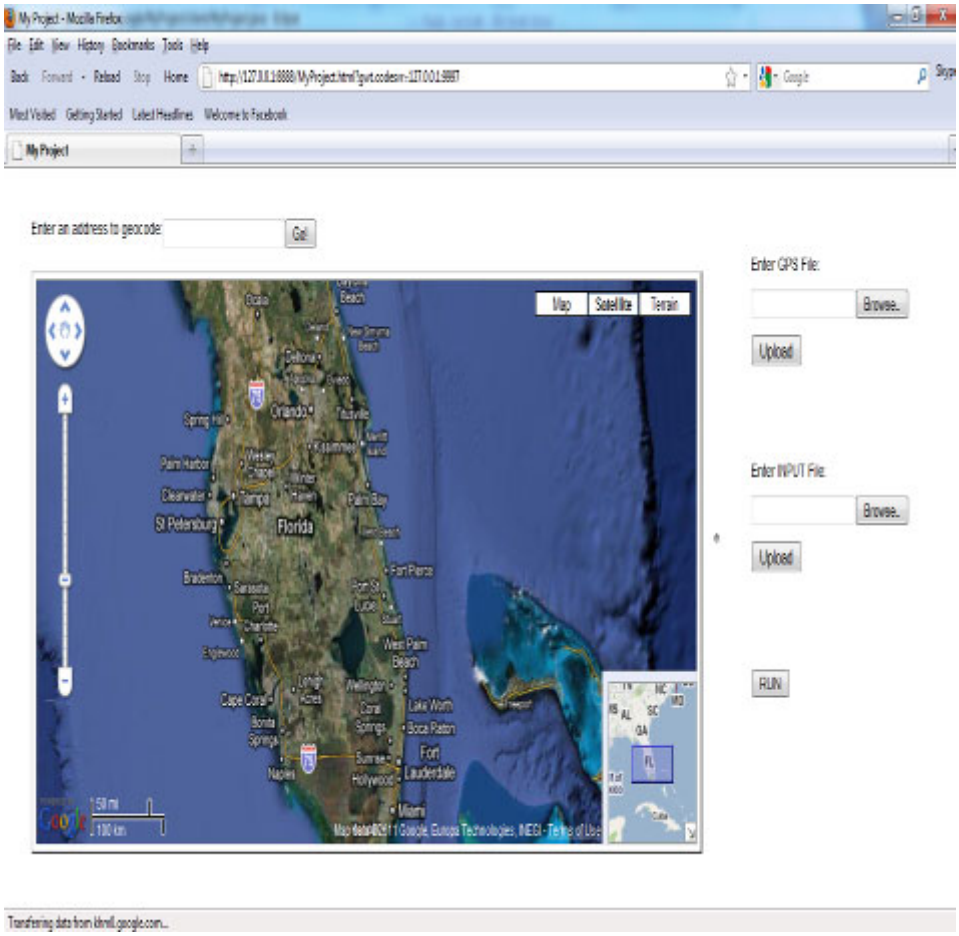

Figure 3. Google Map overview

Another feature implemented is geocoding. This allows the user to navigate to a place based on the name of the location or the GPS co-ordinates. By typing the name or the corresponding GPS co-ordinates in the space after "Enter an address to geocode" and click "Go!", the map shifts to the place of interest and a marker is placed at the corresoding point (Fig.4).

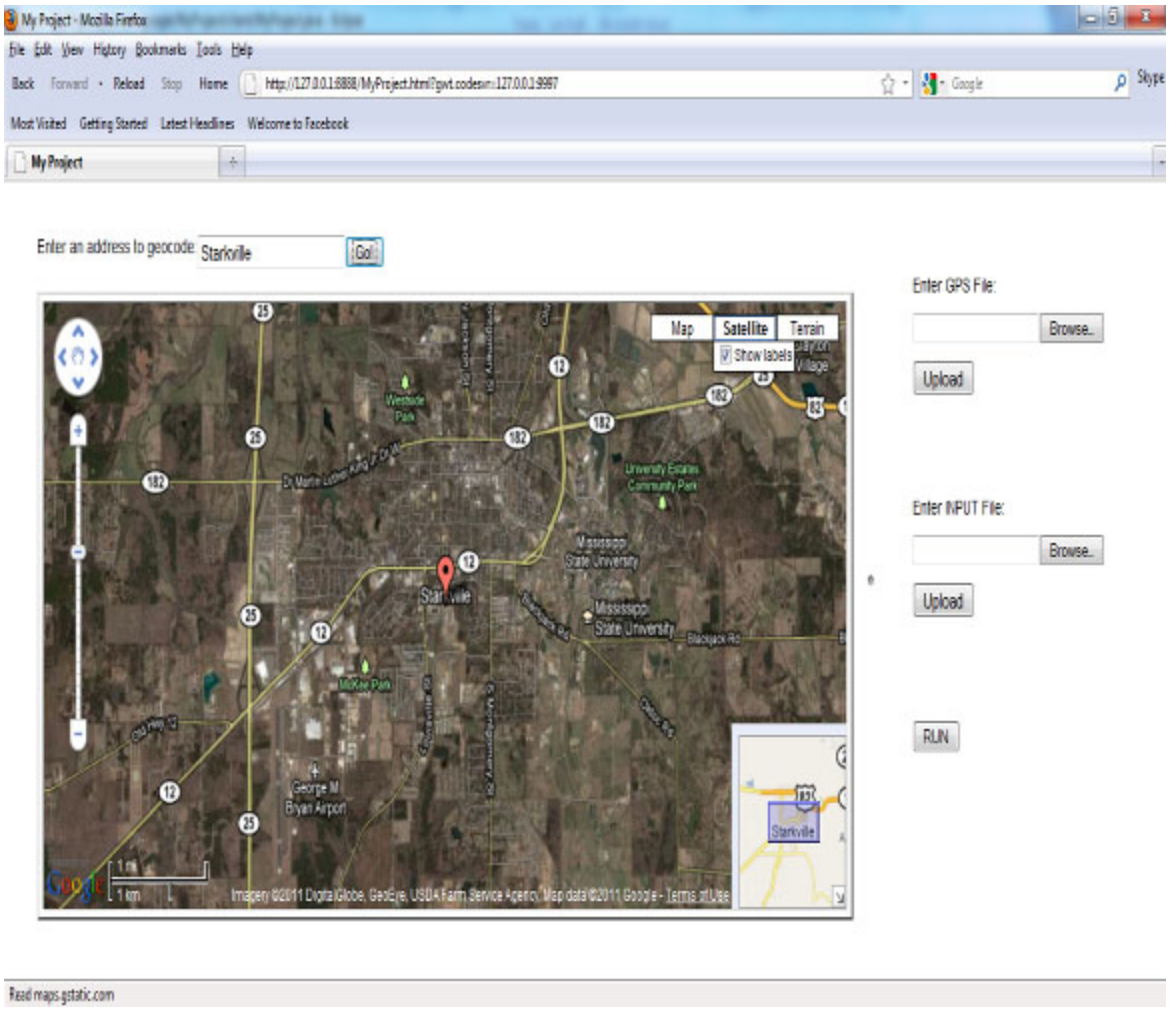

Figure 4. Google Map Geocoding

The necessary steps to be followed by the user to interact with the web portal are:

1. The user must upload the GPS co-ordinates file of the field of interest by providing the URL of the path of the specified file as input to the GUI (Figure 2)
2. The GPS points are shown in the form of markers on the Google Map (Figure 5).
3. The user must now upload the input file containing the reflectance GPS co-ordinates of the same field by providing the URL of the path of the specified file as input to the GUI. A marker is placed at each GPS co-ordinate of the individual sample (Figure 5).
4. A text box window showing the "Input file has been loaded" appears, and the user can click "OK" (Figure 6).
5. By clicking the "RUN" button the user request for the nematode detection service, which actually implements the proposed methodology and returns the nematode count as response. The nematode population at each sample is shown in a pop-up window above the corresponding marker (Figure 7).

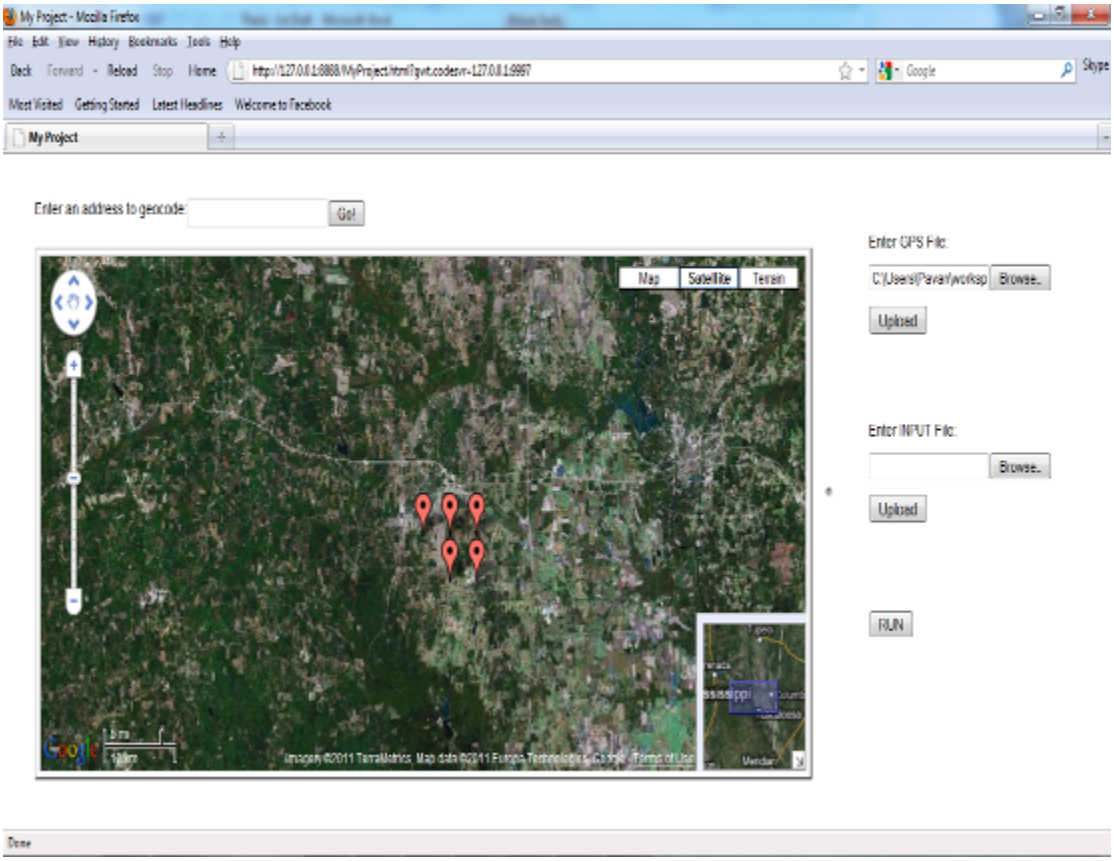

Figure 5. Uploading a sample GPS file

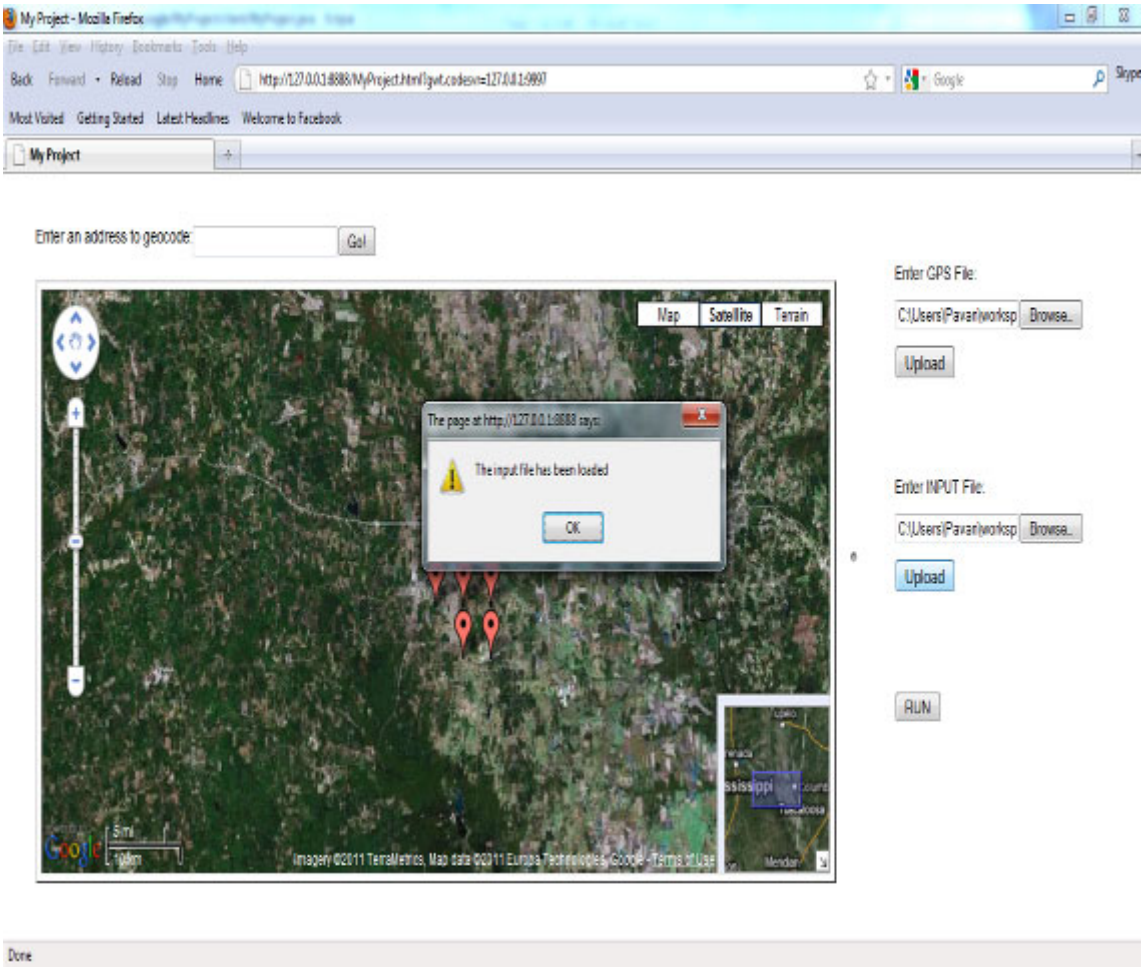

Figure 6. Uploading a sample input reflectance file

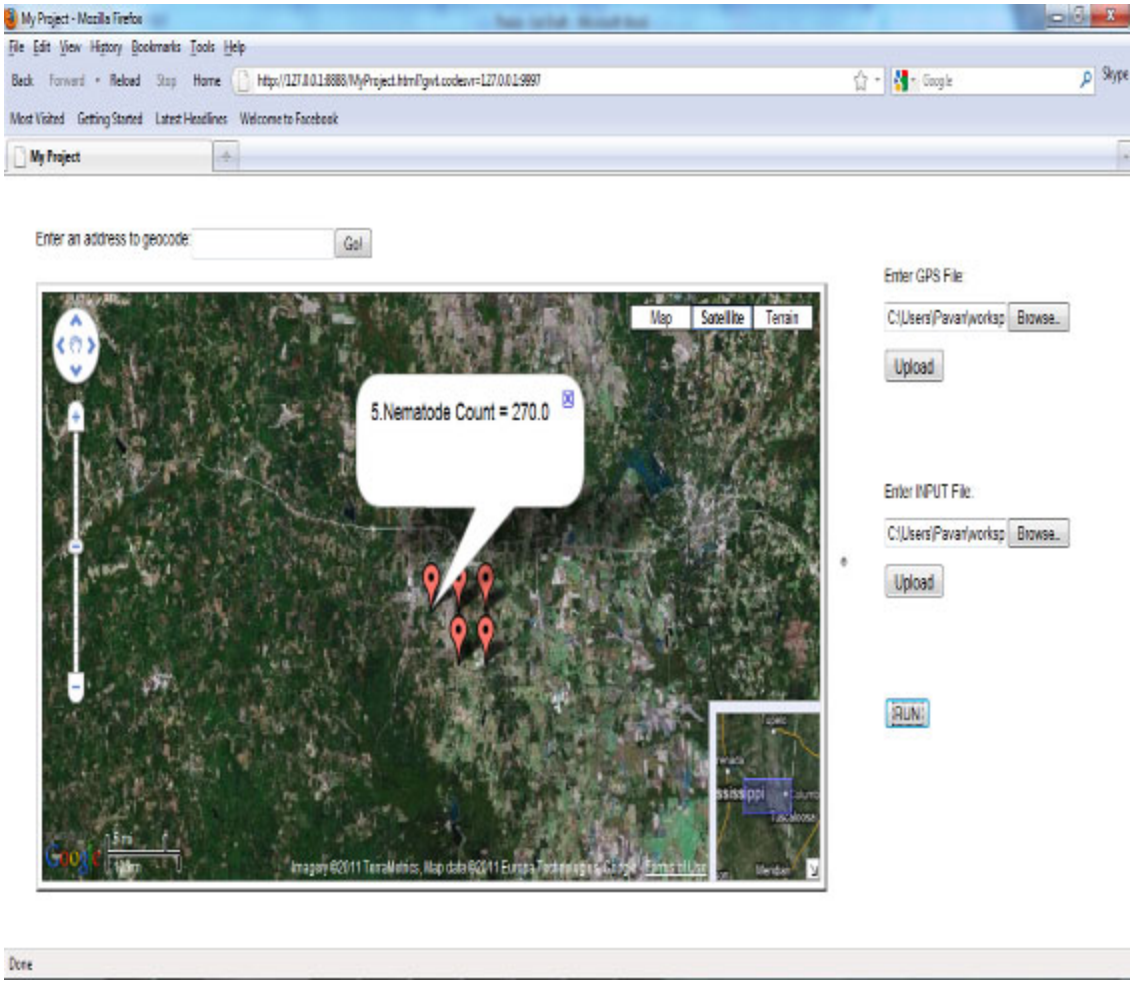

Figure 7. Displaying the Nematode count after running the models

Methodology Algorithm

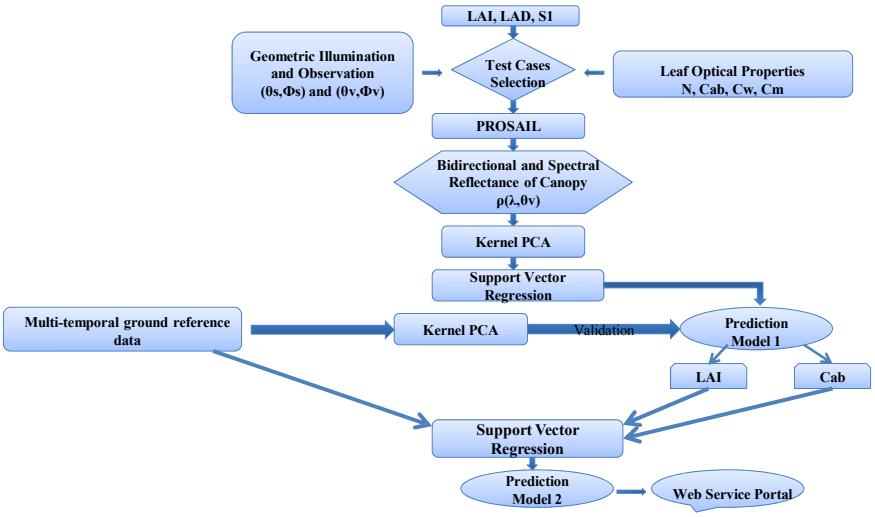

Figure 1. Block diagram of the proposed methodology for estimation of Nematode Infestation in cotton crop

Disclaimer

The interpretation of data presented may change with additional experimentation. Information is not to be construed as a recommendation for use or as an endorsement of a specific product by Mississippi State University or the Mississippi Agricultural and Forestry experiment Station.