Tianjin Daxue Xuebao (Ziran Kexue yu Gongcheng Jishu Ban)/
Journal of Tianjin University Science and Technology
ISSN (Online):0493-2137
E-Publication: Online Open Access
Vol: 56 Issue: 08:2023
DOI 10.5281/zenodo.8296356

IOT BASED TOMATO FLEA BEETLE PEST PREDICTION USING NAÏVE BAYES ALGORITHM FOR SMART FARMING

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Abstract

Insect pest have great influence in vegetable crop growth. It can be minimized by prediction of insect pest using environmental parameters, IOT and machine learning algorithms. The directly sensed environment conditions are used as input to the machine learning model to make binary decisions regarding the pest population according to the prevailing environmental conditions. After implementation in field 89.2% accuracy have achieved by using naïve bayes binary algorithm. The f1, recall, precision and support evaluation metrices have been used for algorithm evaluation. It is highly recommended for formers to increase the yield of vegetable crop.

Index Terms: Internet of things (IoT), Insect Pest Prediction, Naïve Bayes, Smart Farming

1. INTRODUCTION

The smart farm is a concept of using modern sensing and automation technologies to leverage of the farm operations, based on directly sensed data [1]. Smart farms intend to automate the process to improve productivity with the conservation of resources [2]. Smart farms intend to adapt the process with changes to produce more for improvements in agriculture [3]. A smart farm intends to improve remote monitoring of the physical environment for the efficient use of the resources [4, 5]. Smart farming automatically control the growth environments of crop.

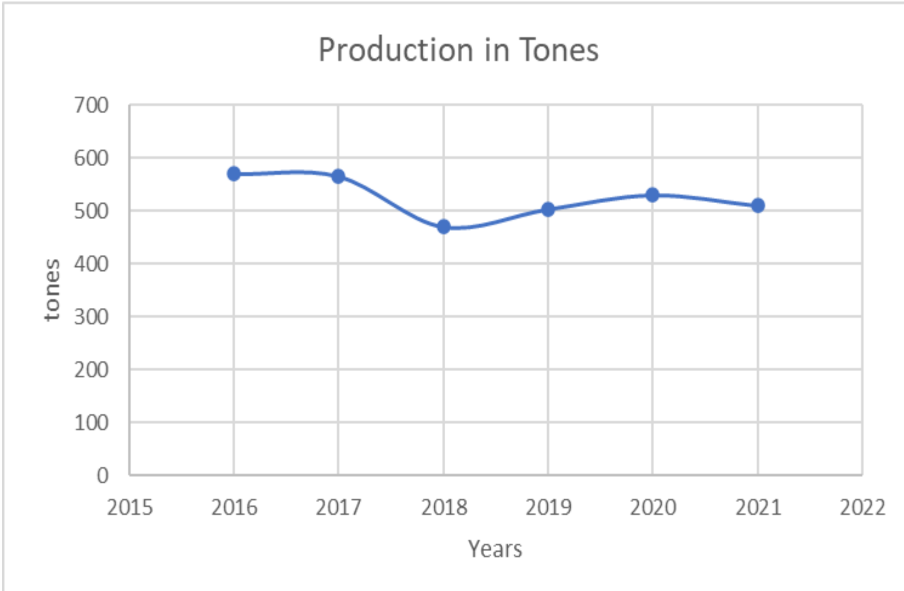

Fig 1: Tomato crop production in Pakistan from 2015 to 2021

Tomato originated in the premises of Western coastal plains of South America. Pakistan is an agricultural country with a major contributor to national income. More than seventy percent (70%) of the population is directly or indirectly associated with agriculture. Agriculture is the backbone of the economy, with an 18.9% contribution to Gras Domestic Product (GDP) [6]. Punjab and Sindh province is the major agricultural land areas. Major crops of the area are vegetables, wheat, cotton, sugarcane, and rice. These five crops are 75% of the total crop values produced in the area. Agriculture is a source of foreign exchange for the country by exporting rice, mangoes, Vegetables and many other agriculture products. Agriculture in Pakistan is suffering from major problems of production and yield due to many environmental problems. The issues become severe with the severe pest attacks on vegetable crops. In recent month's attacks of the desert, the locust has a significant impact on vegetable crop production. Flea Beetle pest have severe impact on tomato crop.

Tomato is the second main vegetable of Pakistan after onion. It is sown in hot and humid regions of the country. The hot and humid conditions also favor the development of pest hazards. Cotton is severely affected by many different types of pests. A high amount of pesticides are applied each year for the protection of the crop. The growth of tomato [7] in Pakistan is shown in Fig. 1.

The attack of pests flea beetle has a severe impact on crop production and yields due to EIL (Economic Injury Level) or transmits a bacterial, viral, or fungal infection. The loss in production (tons) of the crop in 2015 to 2021 in Pakistan in tons is shown in above Fig.1.

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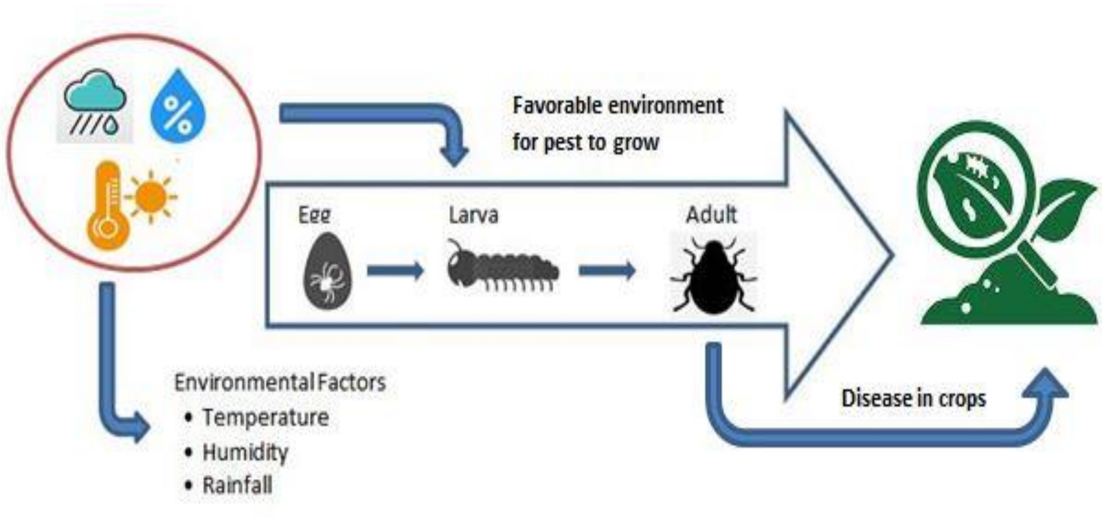

Fig 2: Pest Production Cycle

The Fig.2 shows about external environment factors effecting on Tomato plant and the environment factors have increase the growth of pest (flea beetle).

Internet of Things (IoT) supports the development of Precision Agriculture (PA) and smart farms. Precision Agriculture (PA) is the set of tools and techniques to deal with inter and intra crop field variations to use inputs accordingly. Precision Agriculture (PA) solutions are evaluated on agronomic, economic, and environmental impacts. Precision Agriculture (PA) objective is to improve yield and crop production with judicious use of resources [8]. IoT can perform a significant role in the prediction of whitefly based on environmental factors.

2. LITERATURE REVIEW

Sirisha Adamala et al. [9] proposed the Internet of Things (IoT) and cloud integration for farmer decision support systems. Tan [10] suggested the solution for cloud integration in agriculture applications to convey data to the users. Li Tan proposed a Decision Support System (DSS) of orchids with cloud integration for the information accessible to the end-users. Min-Sheng Liao et al. [11] proposed monitoring of the Phalaenopsis orchids environment using the Internet of Things (IoT) capabilities.

Xiaojie Shi et al. [12] reviewed IoT applications in agriculture with special emphasis on protected agriculture. The study explored the IoT applications in a protected environment for plants and animals. Internet of Things (IoT) for Smart Precision Agriculture and Farming in Rural Areas.

K.V. Raghavendra et al. analyzed the impacts of weather conditions on pest attacks in cotton. The study used the multiple linear regression models to find the correlation between the weather conditions and pest attacks. Regression models are fitted for environmental conditions and pest attacks. The accuracy of the model is judged in terms

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of mean errors and root means squared errors [13]. Jun Liu and Xuewei Wang proposed deep learning-based tomato disease and pest attack identifications. The study used the deep learning approach of tomato plant image preprocessing, extraction, and classification for the identification of the disease impacts on tomato. The study proposed the Yolo V3 algorithm for tomato disease and insect pest attack detection. The proposed Yolo V3 algorithm is more accurate with lower detection time as compared to other relevant algorithms [14].

Shinde and Kulkarni [15] developed a research Proposed system based on 4 modules, wireless sensor network, cloud storage, machine learning prediction algorithm and notification system. In this system different sensors are installed in farm that take temperature, humidity values and send data to the sever and where prediction is made using machine learning algorithm which predict the disease of crop using the training and already feed dataset. Last module contains notification system that alerts the farmers through text message.

Sakhare, et al. [16]developed a system for farmers to take better decisions about their crops by tracking their crops and searching about various diseases. This system is using a prototype that is made up of raspberry Pi as a controller and hardware like moisture sensor and a motor that has on/off switch. Farmers will be able to take better decisions about their crops and production would get better.

Another research done by Lee, et al. [17], in which a system is proposed that provides advance prediction information of diseases and insect pests so that farmers can promptly control them with minimum crop yield penalty. As a result, rice farmers can use this model in the field to help them to make early and rapid control decisions

Ntihemuka and Inoue [18] did same kind of study and combined different sensors devices using wireless sensor network and using KNN algorithm to monitor 8 different environmental factors to prevent pests and diseases caused by them. Different sensors are connected through breadboard jumper wiring on Arduino Board as microcontroller Data is collected through these planted sensors and sent to sink node using ZigBee wireless communication node. After classification of received data, predictions are made to increase the yield and improvement of farm performance.

Azfar, et al. [19] compiled a comprehensive information in a review article for monitoring of agriculture fields for insect pest prediction using wireless sensors network. The purpose of this research is to find the solution for complex situations in a biotic stressed environment and to gain best yield at low cost application of insecticide. In this research, no of WSN applications are needed to increase on industrial scale.

After literature review it is observed that IOT extensively used in smart farming for gathering environmental parameters and make early prediction of pest attack. It also observed that previous studies more focus on detection not on prediction.

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3. MATERIAL AND METHODS

These directly sensed environmental parameters are used to find mean monthly of these parameter observations to make predictions accordingly. For each type of prediction, the data is arranged accordingly. The outcome of the Machine learning model is validated by direct field observations. In the case of the non-validity, the result re-added into the model to improve the accuracy of the model. The model is fitted again and again using the direct field observations.

3.1 Equipment's used

To read data-values from environmental like temperature, humidity, and rainfall, we used following components.

1. Arduino
2. DHT22 (Humidity and Temperature Sensor)
3. FC 37 Rain Sensor

3.2 The prototype of model

The prototype model shown in Fig. 3 consists of temperature, humidity, rain and wind speed sensors with wifi Arduino board and transmitter to add wireless transfer capability implemented in field of crop. The data is transferred to the IOT server and at server machine learning algorithm naïve bayes predict the pest to the farmers using android app.

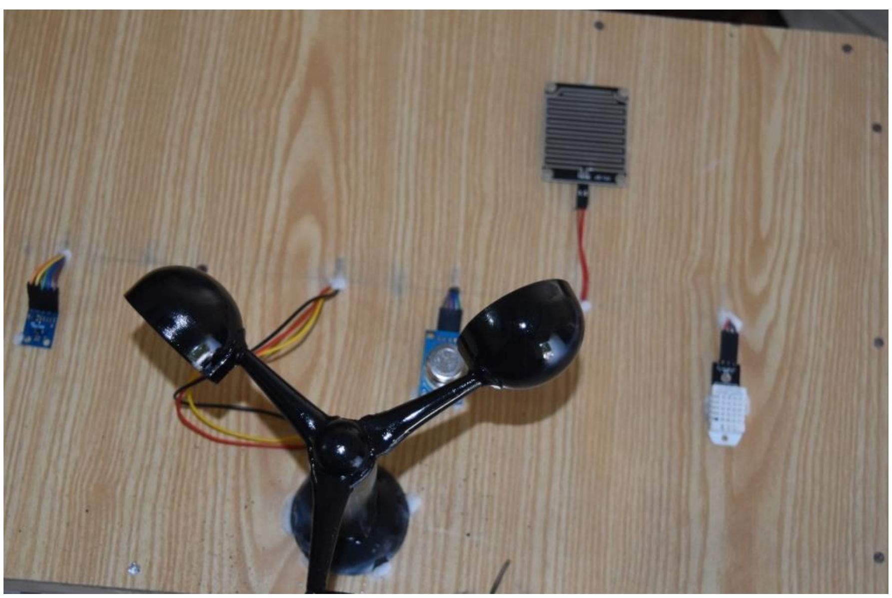

Fig 3: Protoptype model in the field

In Fig. 4, the architecture of the temperature and humidity sensor node is shown. The node is developed using the DHT-22 sensor. The both nodes of model shows the Arduino board is used to process the data from the sensor.

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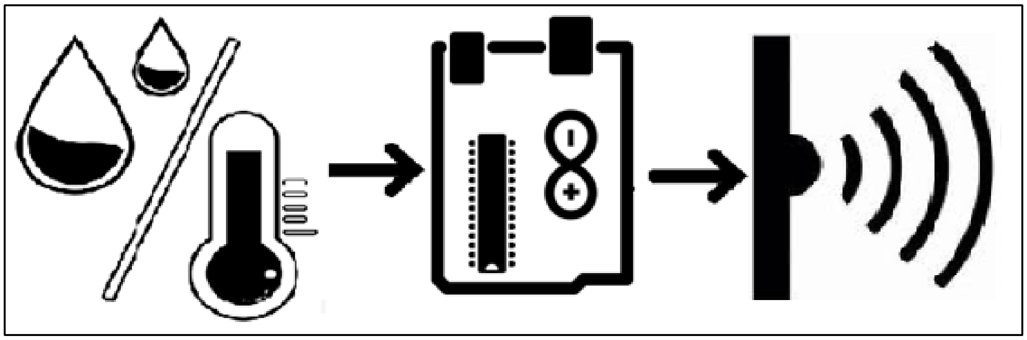

Fig 4: Temperature and humidity sensor node architecture

In Fig. 5, the architecture of the wind speed sensor node is shown. The node is developed using the wind speed sensor. The wind speed sensor data is captured and transmitted through the transmitter module. The architecture of both nodes shows that the Arduino board is used to process the data from the sensor.

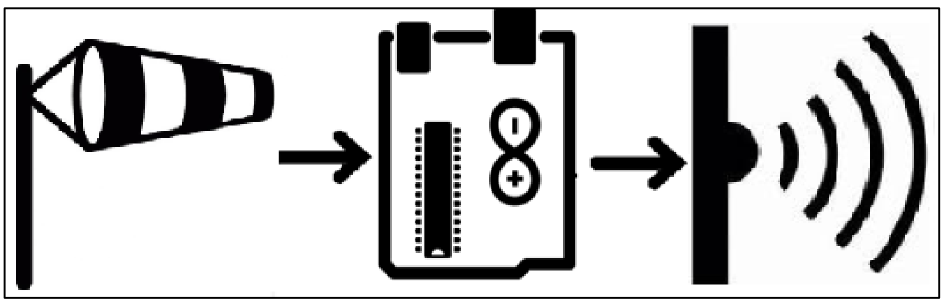

Fig 5: Windspeed Sensor node architecture

In Fig. 6, the architecture of the rain sensor node is shown. The node is developed using the rain sensor. The rain sensor data is captured and transmitted through the gateway. The architecture shows the Arduino board is used to process the data from the sensor to the transmitter.

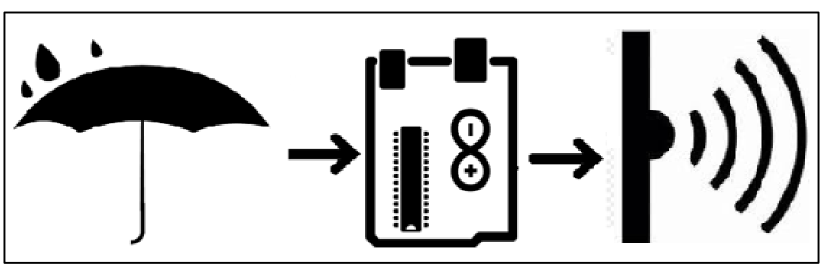

Fig 6: Rain Sensor node architecture

The architecture of the gateway mode is shown in Fig. 7, where the receiver module collects data from each sensor node of the input layer. The data from the receiver is transferred to the server. The data from each sensor node is discriminated based on codes attached to the data transferred by different nodes. The received data is transferred using the Wi-Fi module. The Wi-Fi module transfers the data to the server using the Wi-

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Fi connection to the Internet. The raw sensor data from the input layer is transferred to the storage layer through the Internet.

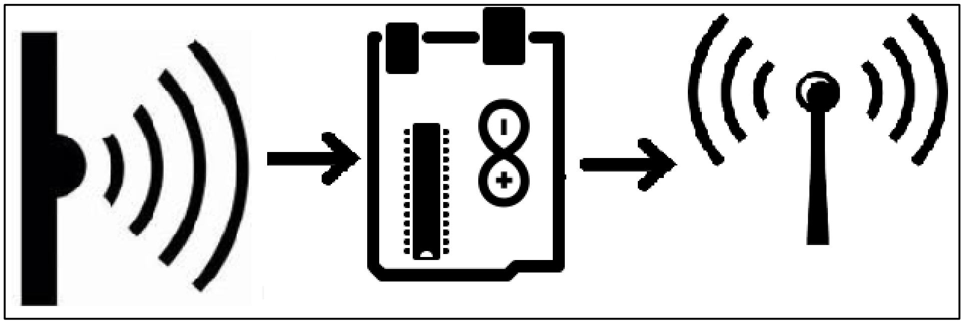

Fig 7: gateway node Architecture

Naïve Bayes is a classification technique dependent on Bayes' Theorem with a supposition of freedom among predictors [20].Mathematically it can be written as

$$(R/S) = ((R|S)P(R))/P(S) \quad (1)$$

Where "R" and "S" are the events where Event "R" is also called evidence. "P(R)", is the probability of event "R", also called prior likelihood of "R", "P(S)" is the likelihood of event "S" also called posterior likelihood of the event "S", "P(R/S)" is the likelihood of event "R" given that event "S" has already occurred.

4. RESULTS AND DISCUSSION

The pest prediction approach of Flea Beetle is an effective approach capable of taking true decisions based on Naïve bayes Model. Use of this approach for environment monitoring that is based on sensors, is an exciting new idea using Naïve Bayes.

We used Naïve bayes and binary classification model to predict environmental type. Naïve Bayes has already implemented in many fields and research areas. We trained Naïve Bayes on our data and then we tested this trained Naïve Bayes by providing some more data taking from fields. We evaluated attained output of our trained Naïve Bayes with the formula given below:

$$Accuracy = Correctly \frac{Predicted}{TotalPredicted} * 100 \quad (2)$$

We took 890 samples and validated it on 390 sample. 89% accuracy achieved and accuracy gradually increased after repeating several training rounds. The Naïve Bayes algorithm binary classification designed in python language with sklearn library. The f1 measure, Recall and precision the evaluation metrics for the prediction of Flea Beetle is described in Table 1.

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Table 1: Evaluation Metrics

Class	F1	Recall	Precision
0.0	0.61	0.33	0.81
1.0	0.92	0.95	0.82
Weighted Avg	0.82	0.90	0.80

The Fig. 8 represents the environmental data temperature, humidity and rainfall of 2019 from 1st June to 15 October.

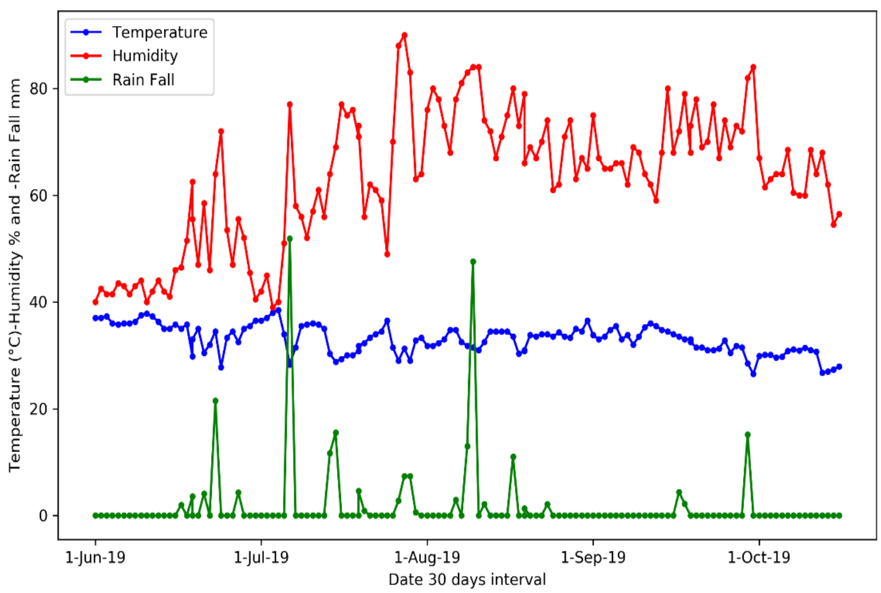

Fig 8: Temperature, humidity and rainfall data of 2019

In Fig.8 red line represents the humidity, blue line represents the temperature and green line represents the rainfall data which is collected from the field. The Fig. 9 represents the environmental data temperature, humidity and rainfall of 2020 from 1st June to 15 October and red line represents the humidity, blue line represents the temperature and green line represents the rainfall data that is collected from the field.

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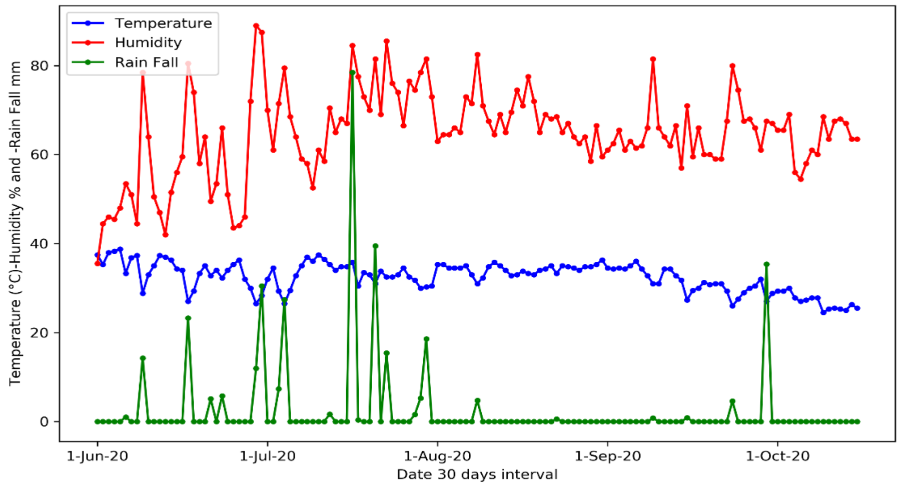

Fig 9: Temperature, humidity and rainfall data of 2020

In Fig. 10 represents the actual and predicted values from the field evaluation and collected 95% accuracy rate during field evaluation.

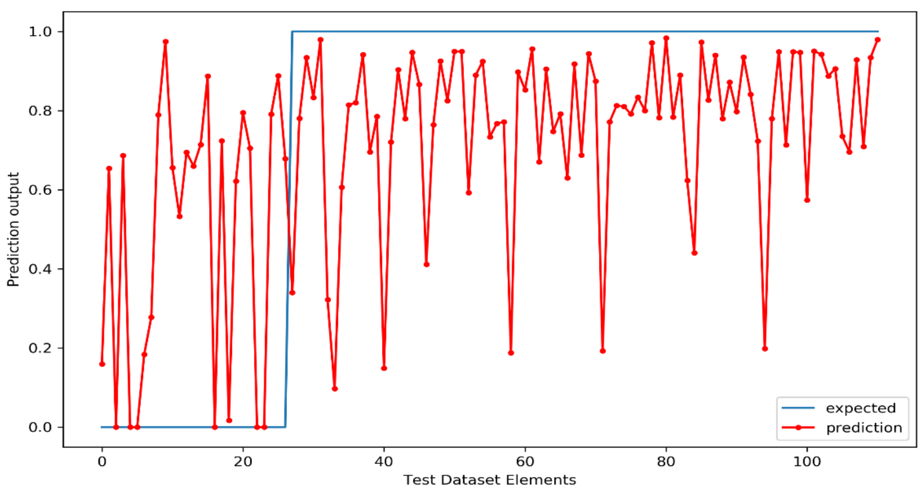

Fig 10: Actual and Predicted Values

5. CONCLUSION

In our proposed research work, we created a prediction system that predicts the probability of pest attack on rice crop using Naïve Bayes. It monitors and detects intensity of different environmental factor like environmental temperature, relative humidity and rainfall. Our proposed system is divided into various modules i.e., sensor base module for environmental data collection for timely control application and Naïve Bayes module for data analysis and a notification system.

Detailed working of proposed system is broken up in below given steps;

1. Climatic data collection by environmental monitoring system based on Arduino and different sensors such as DHT22 (Temp, Humidity) and FC-37(Rainfall).
2. Recording of respective values in system for analysis.
3. Data analysis following by Naïve Bayes model.
4. Displaying the generated results of planted sensors using android app.
5. Informing farmers about the current environmental situation of their crop to take necessary steps.

Data will be collected using sensors. To do this, two sensors will be used, namely, relative humidity and temperature sensor, and rainfall sensor. The proposed system collects the data of current environment using sensor and a hardware device Arduino as a microcontroller.

In future those factors that have the greatest influence pests in climatic can be extracted to optimize the input and output results of the proposed model, and to improve the accuracy of prediction.

Therefore, more sensors could be added in existing system such as light sensor, soil moisture sensor and air monitoring sensor to check more environmental properties to make predictions that are more accurate.

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