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Fuzzy Inference system for soil fertility crop prediction

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Abstract

Economic growth of different countries depends upon agriculture. One of such country is India. Agriculture is inspired by correctly identifying soil for harvesting crops. The technology to this end plays critical role. This paper proposed a fuzzy based mechanism for detecting the fertility of soli. For this purpose, dataset corresponding to soil is extracted from Kaggle. The dataset attributes include levels of Nitrogen, phosphorous, potassium and pH levels. Nutrients levels of these attributes fed into the fuzzy system. Three predictors including Ph levels, Nitrogen and phosphorus are major constituents of soil fertility as detected from correlation analysis. This study concludes that fuzzy based system is effective enough in predicting the fertility of cultivating crops including banana,maize,rice, grapes coconut etc.. This means Fuzzy based inference system (FIS) can be used for effective decision-making regarding soil fertility.

Keywords: Fuzzy system, Soil fertility, Inference system

Introduction

Decision making in agricultural environment is critical. Decision making process in this aspect may involve two or more options. Decision making process could be effective in the presence of fuzzy based inference engine. To predict soil fertility,(Warudkar and Dorle 2016) discussed the characteristics of soil based on remote sensing. Mining based strategies including clustering, segmentation and classification werediscussed for fertility detection. The issue can be determining predictor variables from the dataset. In addition to the mining-based strategies, (Nie et al. 2017) proposed sensor-based mechanism for identifying the nitrogen levels from the soil. Nitrogen is one of the key components for the detection of fertility of soil. Proportional amount of nitrogen within soil can be good for harvesting crops. Issue of energy consumption associated with sensors must be tackled to reduce the inaccurate prediction and loss of packets as discussed in (Li et al. 2017). Energy conservation protocols were used to ensure better stability in terms of energy consumption. LEACH protocol as discussed in (Kumar 2014) can be used for enhancing energy efficiency associated with sensors.

This paper proposed a unique fuzzy inference system for the detection of soil fertility in India. The mechanism uses dataset derived from the Kaggle. Three classes labelled as banana, coconut, grapes and many more are classified through the proposed approach. Rest of the paper is organized as under. Section 1 gives the in-depth analysis of the soil fertility and use of sensors for fertility detection, section 2 gives the literature survey of techniques used for the

crop identification that could be effective within Indian soil, section 3 gives the methodology of work, section 4 gives the performance analysis and result, and last section gives the conclusion.

Literature survey

Indian economy is greatly depending upon the agricultural sector. Fertility of soil impact the growth of growth. To this end, farmers require to make decision regarding which crop can be best for the soil. (Sinfield, Fagerman, and Colic 2010) proposed sensor-based mechanism for determining fertility of the soil. Macro nutrients were effectively examined using this mechanism. Issue with this approach is energy efficiency of sensors. Energy conservation issues with sensors was discussed by (Khan et al. 2015). This approach suggested that sensors should be employed based on energy they possess. Sensors must be labelled based on higher to lower energy. Higher energy sensors must be used for nutrient analysis from soil as suggested by (Amrutha, Lekha, and Sreedevi 2017). Furthermore, soil fertility can be dependent upon the presence of nutrients such as phosphorous, pH levels, nitrogen and carbon as discussed by (Puno et al. 2017). This approach effectively determines the soil fertility by considering these nutrients presence in proportioned among within soil. Most of the crops that becomes damaged was because of lack of these nutrients. Lack of nutrients causes disease within crops. Disease prediction within crops using data mining was proposed by (Sushma B, 2016). Disease prediction within the crops using suggested mechanism includes image processing mechanisms as well. first, remote sensing images derived from UCI were fed into pre-processing mechanism. Gaussian filter discussed by (Ma et al. 2017) was used to reduce the noise from the remote image. Segmentation mechanism ensures extraction of features from critical parts of image. Classification using KNN was done. Two class of crops including Maize and Yam was predicted using said mechanism. (Masrie et al. 2019) proposed optical sensor-based mechanism for the detection soil fertility. The optical sensor was placed near the soil and light emitted from the sensor passed through soil. Intensity of light reflected was analyzed for determine the presence or absence of nutrients. Maze, Yam and Cassava crop was detected for harvesting using this mechanism.

The mechanisms discussed has research gap that degree of misclassification was high. Noise present within datasets was not effectively handled that resulted in low classification accuracy. Next section discussed the methodology of proposed work used to tackle the issues of existing work.

3. Methodology of proposed work

The proposed work uses fuzzy inference system to conclude fertility of soil. The structure of dataset used for fertility detection is given within table 1

Attribute	Description
N	Nitrogen levels
P	Phosphorus Levels
K	Potassium levels
Temperature	Temperature of environment
Humidity	Humidity levels of crop
pH	Water levels
Rainfall	Rainfall in environment
Label	Soil prediction

Table 1: Dataset description

The steps performed for classification of soil is given as under

Input: Dataset with N,P,K, Temperature, Humidity, pH , Rainfall)

- Correlation between the Label and rest of the fields are evaluated.
- Highest correlation attributes including P,N, pH are fed into the fuzzy inference system
- Fuzzy set is created for dependent and independent variables with membership function. For input variables such as pH levels, membership function was defined to contain “low”, “medium” or “high” values.
- After this inference rules are defined. These inference engine takes the membership function and then produce the output according to rules defined.
- The set of dependent variables are then generated based on set of independent variables.
- The result obtained used to predict the crop effective for the particular soil.

The system architecture used within the proposed system is defined within figure 1

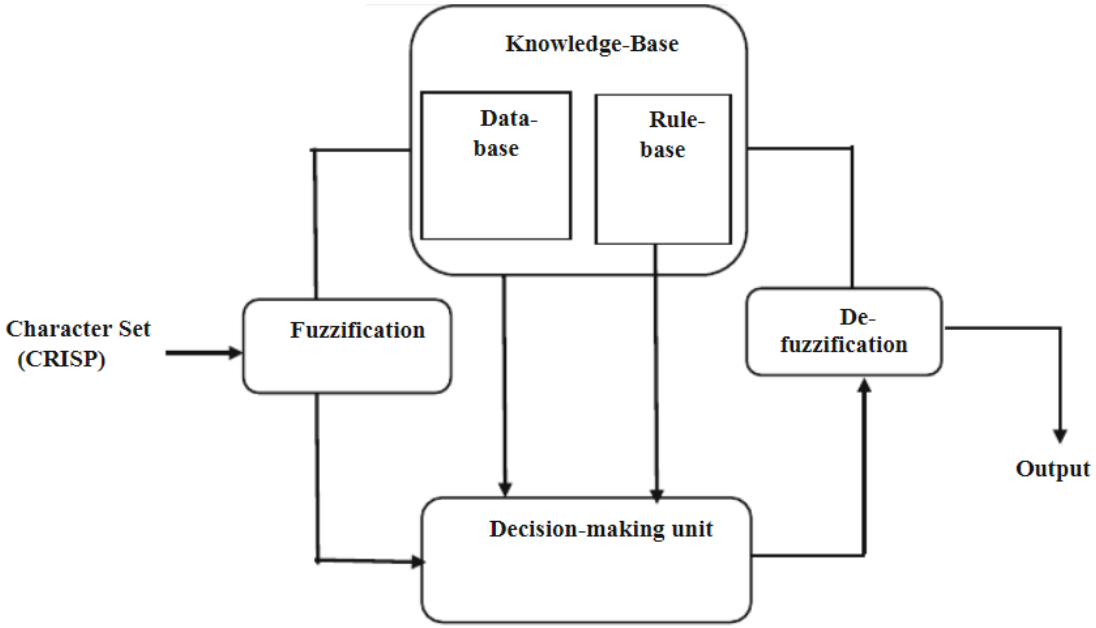

Figure 1: system architecture corresponding to fuzzy inference system(Arogundade et al. 2021).

4. Performance analysis and results

This section highlights the result generated from the fuzzy inference-based system for detecting crop fertility for presented soil. The hardware and software requirements corresponding to implementation of this work includes Windows 7 or higher 64-bit operating system, 1 GB or higher RAM, 10 GB of free HDD, MATLAB 2018 or higher.

The variation of P,N and pH levels and the results are given within table 2

Attribute	Intensity level	Output
P	0.2	Rice
N	0.2	Rice
pH	0.2	Rice

Table 2: Output corresponding to values of P,N,pH

The plots corresponding to the table 2 is given in figure 1

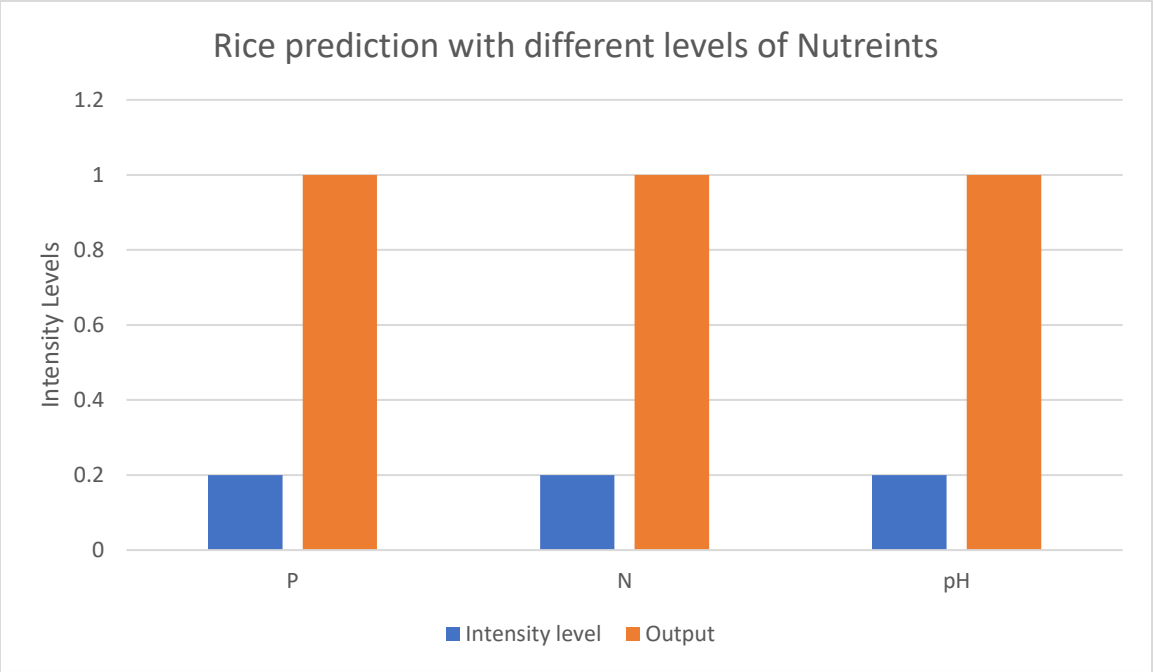

Figure 1: Rice prediction with different levels of nutrients

"1" indicates the rice crop. As the values of the nutrients are varied different set of crops are generated as output.

Attribute	Intensity level	Output
P	0.3	Maize
N	0.4	Maize
pH	0.4	Maize

Table 3: Indicates the maize production with different values of P,N and pH

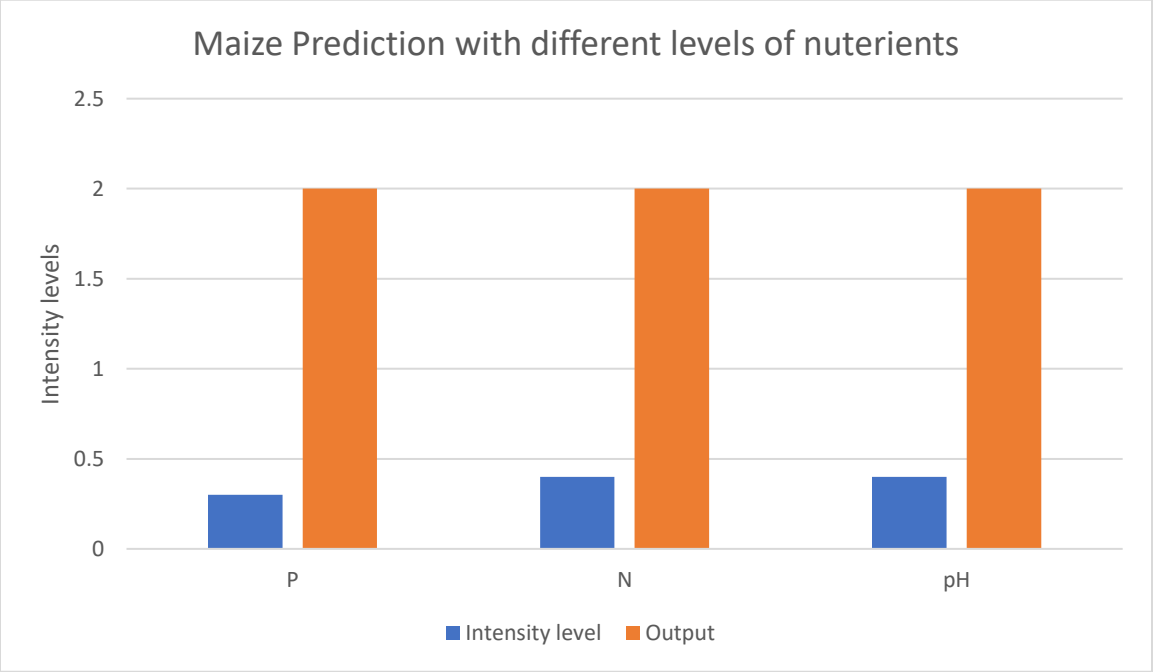

Figure 2: Crop prediction with different levels of P,N and pH

The value of P, N and pH when varied to beyond 0.4 banana ,coconut and grapes are predicted. The results are shown within table 3

Attribute	Intensity level	Output
P	0.4	Banana
N	0.5	Coconut
pH	0.6	Grapes

Table 3: Crop prediction with asymmetrical values of P,N and pH

The result is visualized within figure 3

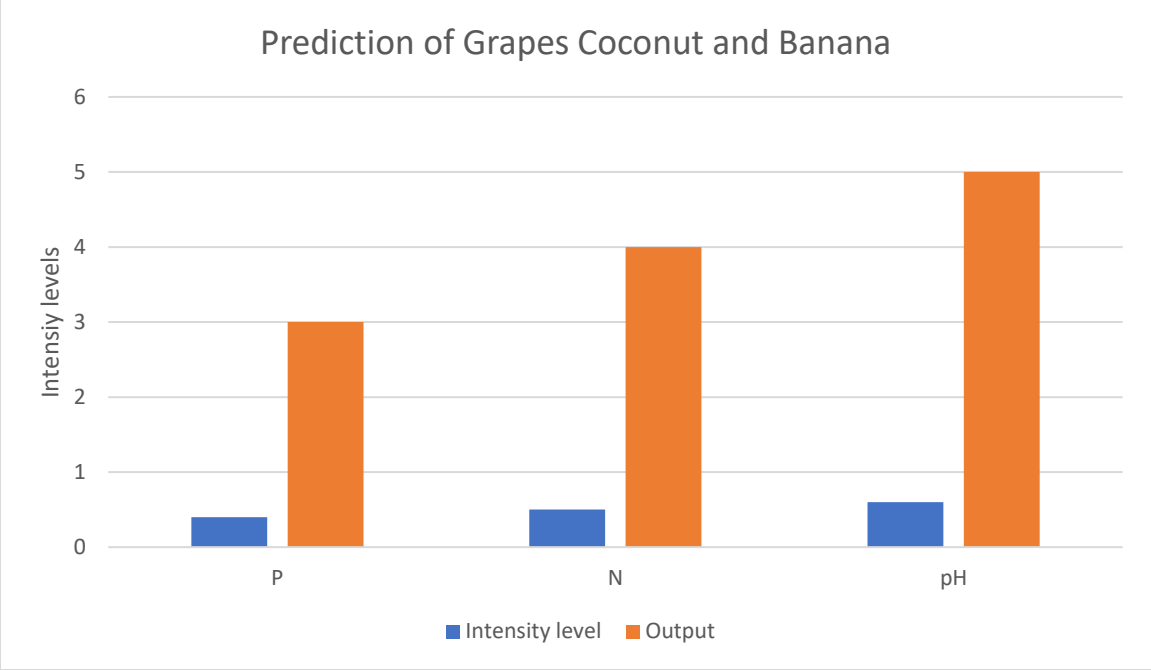

Figure 3: Prediction of Grapes, Coconut and Banana

"3" refer to banana, "4" refers to coconut and "5" refers to banana.

5. Conclusion

The proposed mechanism uses fuzzy inference system predicts the soil fertility. Soil fertility detection mechanism ensures that proper crop can be predicted corresponding to the nutrients possessed by fuzzy inference system. The results also indicates that the uniform values of P,Ph and N gives the common crop like maize and asymmetrical values of nutrients yield coconut, banana and grapes. The correlation suggested that P,N and pH attributes have highest correlation with the prediction output.

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