LCC Prediction of Rice Fields from Drone Imagery Using K-Means Clustering and SVM

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***Abstract*—Determining the right amount of nitrogen in rice fields is crucial to avoid wasting urea, a fertilizer commonly used in these fields. Knowing the nitrogen level helps us to determine the amount of urea needed. By doing so, we not only protect the environment but also reduce water pollution caused by excessive use of urea in the rice field. Currently, a Leaf Color Chart (LCC) is used to measure the nitrogen level in the rice fields. However, many farmers in Bangladesh either don't use it or don't have access to it. Also, accurately reading the LCC requires proper training. In our project, the goal is to find a way to identify LCC readings in large rice fields using drones. Instead of spending money on training farmers to use LCC, we aim to provide them with nitrogen level information for their fields without any difficulty over a vast area. This greatly benefits the farmers. We used a drone to fly over the rice fields and capture images. After carefully reviewing all the photos and selecting a few, we employed K-Means clustering to identify the 4-6 RGB values. Subsequently, we utilized the SVM Classifier to predict the LCC reading for the rice fields.**

***Index Terms*—LCC, K-Means Clustering, SVM, Nitrogen Level Detection**

I. Background

Nitrogen plays a crucial role in the growth of plants, especially in rice production. Nitrate fertilizer, essential for increasing rice productivity, includes urea, a product subsidized by the government of Bangladesh at 51 taka per kilogram out of the total 81 taka/kg cost. However, only 40% of the applied urea is effectively used, with the remaining 60% being lost through water, air, or soil seepage [1]. Farmers in Bangladesh tend to excessively use urea in rice fields, leading to significant environmental and financial consequences. The repeated use of excessive nitrogen results in soil and water acidity, contamination of ground and surface water, and ozone depletion [2]. To address this, the Leaf Color Chart (LCC) serves as a simple and cost-effective tool to assess the relative greenness of rice leaves, indicating the plant's nitrogen status [3]. Developed by the International Rice Research Institute (IRRI), the LCC involves matching rice leaves with a 4-panel chart, each representing different color categories. The best-matched reading from the chart is considered the LCC reading for that leaf. This process is repeated for 8 to 10 leaves to determine the average LCC reading for the entire rice field. [4].

II. Our Approach

In this study, we aimed to classify rice leaf images captured from drone with certain elevation without directly taking help of leaf color chart. The Leaf Color Chart (LCC), which is a tool used to assess the relative nitrogen status of rice plants. The LCC uses readings from 2 to 5 (Figure-1), where each reading corresponds to a different shade of green on the rice leaves. The LCC readings play a crucial role in determining the amount of urea fertilizer required for optimal crop growth. Our goal was to use this chart to predict the nitrogen status of rice fields and help optimize fertilizer usage to reduce both environmental and financial impacts.

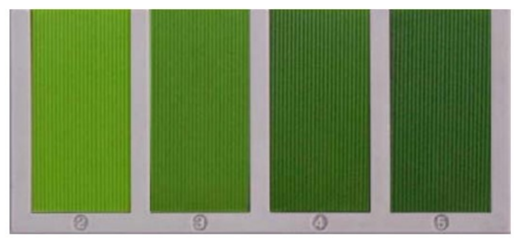

Fig. 1: Four Panel Leaf Color Chart

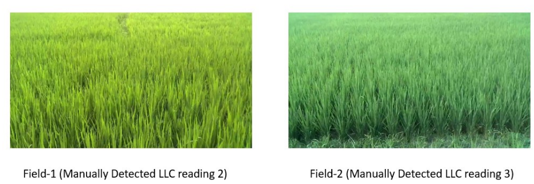

Fig. 2: Drone shot of two rice field with manual LCC reading 2 and 3

To develop the model, we started by creating four base color images, then added two images from rice fields with LCC readings of 2 and 3, which formed our training set. These fields were chosen because they represented different nitrogen status. Next, we selected 8 images from drone-captured video footage of rice fields, ensuring that the images contained a variation in the green shades of the rice leaves. These 8 images were used for testing.

Our approach employed K-means clustering to group the RGB values in the images into 2 to 5 clusters (Figure 3, 4, 5). Table I lists the four most prominent RGB values from the training images. From these clusters, we selected the RGB values with the highest frequency as features for the classification model. We then trained four Support Vector Machine (SVM) models, using between 2 and 5 RGB values as inputs, and evaluated their accuracy. Our results demonstrated that using 4 or 5 RGB values resulted in the SVM model correctly predicting the LCC readings for 7-8 out of the 8 test images.

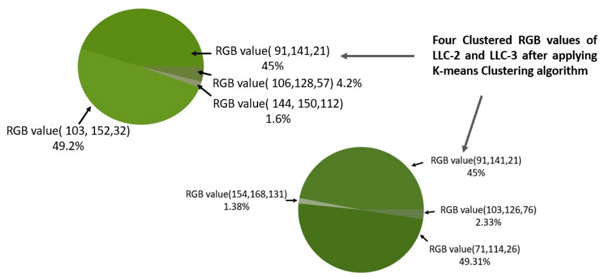

Fig. 3: Four Clustered RGB values of base reading 2, 3

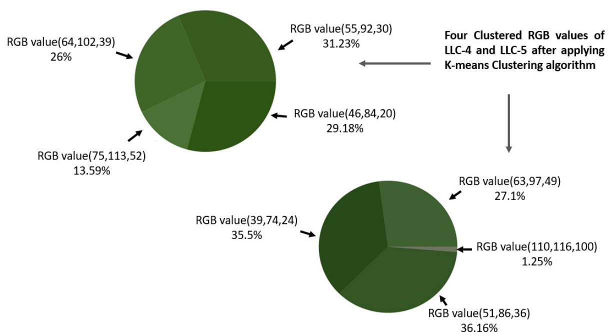

Fig. 4: Four Clustered RGB values of base reading 4, 5

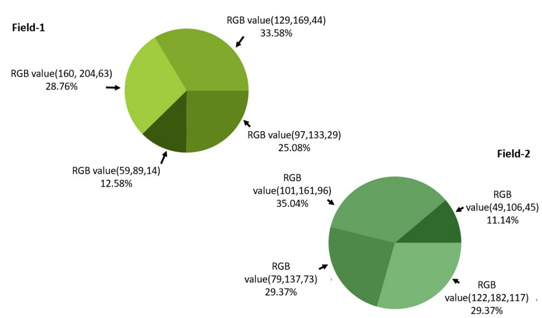

Fig. 5: Four Clustered RGB values of Captured Drone Image

The model achieved 100% accuracy for LCC reading-2 and 87.5% accuracy for LCC reading-3 (see Table I). These results demonstrate the effectiveness of the method in predicting the nitrogen status of rice fields. However, the small dataset—comprising only 6 training images and 8 testing images—likely contributed to the high accuracy, particularly for LCC reading-2, where the limited variation in images may have helped improve performance.

Object	1st RGB	2nd RGB	3rd RGB	4th RGB
LCC-1	(103, 152, 32)	(91, 141, 21)	(106, 128, 57)	(144, 150, 112)
LCC-2	(71, 114, 26)	(82, 125, 38)	(103, 126, 76)	(154, 169, 131)
LCC-3	(55, 92, 30)	(46, 84, 20)	(64, 102, 38)	(74, 113, 51)
LCC-4	(51, 85, 36)	(39, 74, 24)	(62, 97, 48)	(110, 116, 100)
Field-1	(137, 168, 39)	(163, 196, 57)	(108, 136, 23)	(69, 94, 7)
Field-2	(101, 161, 96)	(122, 182, 117)	(79, 137, 73)	(49, 106, 45)

TABLE I: Clustered RGB values of Base LCC colors and Field Images

LCC Reading	No. of Clusters	Total Images	Accurate Prediction	Accuracy (%)
2	2	8	5	62.5
	3		6	75
	4		8	100
	5		8	100
3	2	8	6	75
	3		6	75
	4		7	87.5
	5		7	87.5

TABLE II: Overall Performance

Despite the dataset limitations, our findings highlight the potential of combining K-means clustering and SVM for classifying nitrogen status in rice fields. This method could help optimize fertilizer management practices, reducing fertilizer waste and improving crop yields. Future work with a larger, more diverse dataset would enhance the model's robustness and generalizability, making it suitable for large-scale applications, especially in Bangladesh's agricultural sector. This would further contribute to minimizing the environmental impact of urea fertilizer while supporting better nitrogen management practices.

References

[1] S. Iqbal, "Improvement of the existing usg fertilizer applicator," *Department of Agricultural Engineering, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh*, vol. 7, no. 14, pp. 12–17, 2009.

[2] M. Islam and S. Beg, "Can rules-of-thumb improve fertilizer management? experimental evidence from bangladesh," 2019.

[3] A. S. Islam, M. Rahman, A. L. Rahman, M. Islam, and M. Rahman, "Field performance evaluation of push type prilled urea applicator in rice cultivation," *Bangladesh Rice Journal*, vol. 19, no. 2, pp. 71–81, 2015.

[4] USAID. Use of leaf color chart (lcc). [Online]. Available: https://pdf.usaid.gov/pdf_docs/PA00K938.pdf