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An Identification of Chlorophyll Content using Image Processing Technique and Fuzzy Mamdani Method

Suhartono*

State Islamic University of Maulana Malik Ibrahim Malang, Indonesia;galipek@gmail.com

Abstract

Background/Objectives: To improve an identification of chlorophyll content in leaf, this paper presents an implementation of a supervised learning method based on membership function training in the context of mamdani fuzzy models. **Methods/ Statistical Analysis:** this paper presents a fuzzy rule based algorithm; natural color image in leaf (Red, Green and Blue) is used as the input to the fuzzy mamdani models. The output of the fuzzy mamdani models is value of chlorophyll content. **Results:** The proposed approach was superior to identification of chlorophyll content in leaf using image processing technique and mamdani fuzzy method has higher identification accuracy. **Conclusion/Application:** Finally, the basic difference of value of chlorophyll content between fuzzy mamdani models and the actual was less than 3,1 % on average.

Keywords: Chlorophyll Content, Identification, Image Processing, Leaf, Mamdani Fuzzy

1. Introduction

One of the major components of plant cell is chlorophyll and its content plays an important role in plant functions. There are several physical and chemical methods for chlorophyll content determination. The chlorophyll content on plant can be supported research of photosynthesis[1]. The chlorophyll content can indirectly determine the photosynthetic potential[2-4]. The chlorophyll content in the leaves is closely related to plant nutrient status[5]. Chlorophyll meters have been developed to estimate chlorophyll content[3,6,7].

This is reporting image processing technique for the identification of the chlorophyll content in leaves, from colored images. Haboudane et al., found correlations between chlorophyll content and canopy reflectance particularly in the spectral region from green (550 nm) to red edge (750 nm)[6] whereas the same correlation was found by Kim et al. in the different spectral region ranging in visible light[8]. Spomer et al. described a practical, micro-computerized image analysis method for quantifying leaf chlorophyll content from a monochrome video image[9]. Everitt et al. presented the status and development of such airborne video imaging systems for resource management, with special emphasis on their application in agriculture[10] and in medicine[11]. Anatoly et al. found some relationships between leaf chlorophyll content and spectral reflectance and nondestructive techniques in higher plant leaves[12-18].

Gao estimated canopy's chlorophyll with hyper-spectral remote sensing[19]. The color components of RGB space were nearly related to chlorophyll content of leaves[20,21]. It has remained to be seen whether color components of HSI space are appropriate index for determining chlorophyll content of walnut leaves (WL)[8,20]. Hue, Saturation and Intensity (H-S-I) space is established according to human color perception that is normally limited to visible light. The H and I components are generally related to the wavelength and the amplitude of a light, respectively. S is a component which measures the "Colorfulness" in the HSI space[21]. Smith and Sawwan (1988) described a practical, micro computerized image analysis method for quantifying leaf chlorophyll content from a monochrome video image[21,22]. Everitt et al. (1991) has reviewed the status and development of such airborne video imaging systems and their applications for resource management, with special emphasis on agriculture[23-25].

The aim of this research is to identify chlorophyll content using fuzzy mamdani method and personal computer is

**Author for correspondence*

reported. Design of identification of chlorophyll content used matlabR2008a on windows 7 operating system.

2. Methodology

This research was carried out at networking laboratory, department of information technology, state islamic university of maulana malik ibrahim malang. This research used leaves from soybean plant. Soybean plants were planted on dry land and the soil is infertile. Dose of fertilizer used is organic (200 gram/meter^3), urea (5 g/ meter^3), TSP (triple super phosphate) (5 g/ meter^3), KCL (kaliumklorida) (5 gram/ meter^3). Leaf Data obtained at random from plant at the age of 20 days after planting. Soybean leaf data is trifoliate leaves. Soybean leaf shape as the data is oval.

Data of soybean leaves were collected using chlorophyll meter and scanning process for get to natural color image in leaf (Red, Green and Blue (RGB))in soybean leaf image. The RGB value as input parameters of model were obtained from the average RGB value of each leaf with a size of 100x100 pixels, in Figure 1.

The hardware requirements used to identification of chlorophyll content was chlorophyll meter with the specifications Konica Minolta SPAD 502 Plus and personal computer with the specifications Intel Pentium Dual Core 2.8 Ghz Processor, 8 Giga Byte RAM, 500GB Hard drive, Graphic Card NVIDIA GeForce 8400GS.

The Matlab software under windows operating system was used in this research. Figure 2displays the investigation procedure using fuzzy mamdani aimed at identification of chlorophyll content.

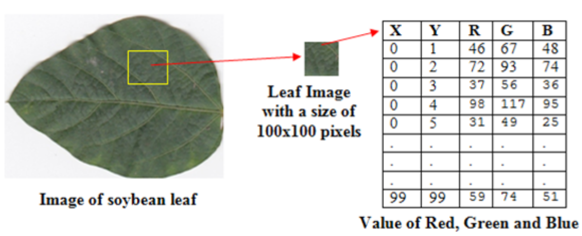

Figure 1. Leaf image with a size of 100x100 pixels.

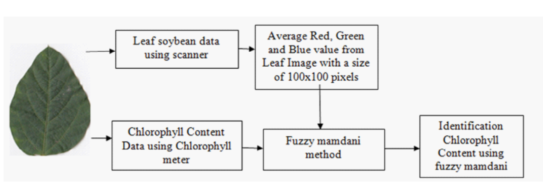

Figure 2. The research methodology for using fuzzy mamdani for identification of chlorophyll content.

3. Discussion

A fuzzy forceful model has been recommended to signify nearby undeviating input/output relation for non-undeviatingsystems[26]. Role of fuzzy mamdani system for identification of input/output relationship for system non linear. This fuzzy mamdani harvest was recycled as tenants for chlorophyllcontent.

In this surveillance, the quantity of chlorophyllcontentwas separated into two amounts: a) 25 records was recycled as identification model for the system of fuzzy, in place of in table 1, b). 5 records is recycled as a comparator to the harvest of fuzzy mamdani, as in table 2. The modeling of show fuzzy mamdani results using matlab software uses three parameter inputs which

Table 1. Data for model of fuzzy mamdani

Code	Chlorophyll Content	Image of soybean leaf		
		Red	Green	Blue
1	45.6	77	90	70
2	44.3	81	96	72
3	42.0	71	86	67
4	40.4	76	97	69
5	42.6	74	89	71
6	38.8	77	91	68
7	39.9	75	93	66
8	40.8	77	90	68
9	40.1	79	95	65
10	43.2	74	89	69
11	31.3	95	117	66
12	39.5	73	97	65
13	43.6	77	90	67
14	38.3	80	105	63
15	33.3	87	113	64
16	41.4	79	96	69
17	32.5	93	118	68
18	41.0	70	89	66
19	34.5	77	101	64
20	42.5	69	89	65
21	42.5	75	91	70
22	45.7	71	89	66
23	46.5	69	84	66
24	44.9	76	93	70
25	41.4	72	93	65

Table 2. Data for comparator

Code	Chlorophyll content	Image of soybean leaf		
		Red	Green	Blue
1	44.2	74	89	67
2	41.4	74	94	69
3	43.3	75	90	69
4	44.8	75	93	69
5	43.3	75	92	67

were Red, Green and Blue in leaf image and one parameter output which was the chlorophyllcontent parameter.

$$\mu_{rlow}[r] = \begin{cases} 1; x \leq 73 \\ \dfrac{76 - x}{76 - 73}; 73 < x < 76 \\ 0; \quad x \geq 76 \end{cases} \tag{1}$$

$$\mu_{rmedium}[r] = \begin{cases} 0; x \leq 73\ and x \geq 79 \\ \dfrac{x - 73}{76 - 73}; 73 \ < x < 76 \\ \dfrac{79 - x}{79 - 76}; 76 \ < x < 79 \end{cases} \tag{2}$$

$$\mu_{rheight}[r] = \begin{cases} 0; x \leq 76 \\ \dfrac{x - 76}{79 - 76}; 76 < x < 79 \\ 1; x \geq 79 \end{cases} \tag{3}$$

A crusty set was designated by a specific role whose assessment is always either 0 or 1.A fuzzy established was distanced through affiliation role that incomes standards any place between 0 and 1. In a fuzzy structure, we influence signify the arrangements of low, medium, and height by the fuzzy affiliation functions[27,28] with affiliation function for Red parameter in formula 1, 2, and 3.

To current the fuzzy affiliation purposes of leaf image as input and chlorophyll content as output in figure 3,

Figure 3 displays the law of fuzzy system to classify the chlorophyll content consideration on the records quantity in investigation ground. With these arrangements, fuzzy relations were distanced. Fuzzy relations might be clarified as the relation among parameter Red, Green and Blue in leaf image to generate chlorophyll content parameter.FuzzyAssociativeMemory (FAM) matrixcanbemade in table 3.

For example, uncertainty the value of Red, Green also Blue are standard (50%), correspondingly, formerly the

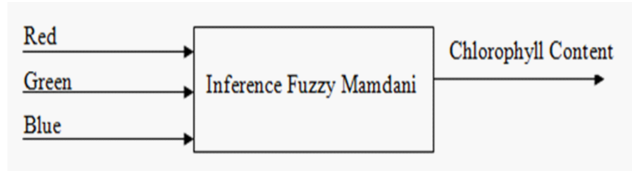

Figure 3. Law of fuzzy arrangement to classify the chlorophyll content consideration.

Table 3. Fuzzy Associative Memory (FAM) Matrix

	Red	Green	Blue
Chlorophyll Low	Chlorophyll Low	ChlorophyllLow	ChlorophyllLow
Chlorophyll Medium	Chlorophyll Medium	ChlorophyllMedium	ChlorophyllMedium
Chlorophyll High	ChlorophyllMedium	Chlorophyll High	Chlorophyll High

value of chlorophyll content is medium. It is then coded as

IF Red MEDIUM AND Green MEDIUM AND Blue MEDIUM THEN ChlorophyllContent MEDIUM

If denotes the value of Red,

Where$\varnothing \in \{$ **Low,Medium and High** $\}$

Δdenotes the value of Green,

Where$\Delta \in \{$ **Low,Medium and High** $\}$

∇denotes the value of Green,

Where$\nabla \in \{$ **Low,Medium and High** $\}$

And B denotes the ChlorophyllContent,

Where**B** $\in \{$ **Low,Medium and High** $\}$

Then, the following equation can be derived

B = $\varnothing$ AND Δ AND

If there are n number of $\varnothing$, Δ, $\nabla$and **B**, this equations follows

B0 = $\varnothing_0$ AND Δ_0AND ∇_0

B1 = $\varnothing_1$ AND Δ_1AND ∇_1

…

Bn = $\varnothing_n$ AND Δ_nAND ∇_n

Finally, the combination of all z values can be derived as follows

B = B0 OR B1 ... OR Bn

In figure 4 to find the actual chlorophyll content value, the output fuzzy set was converted into a numerical value. This process is called defuzzification. There are several possible methods. The centroid method will be used because it is the typical choice for plant growth modelling. The

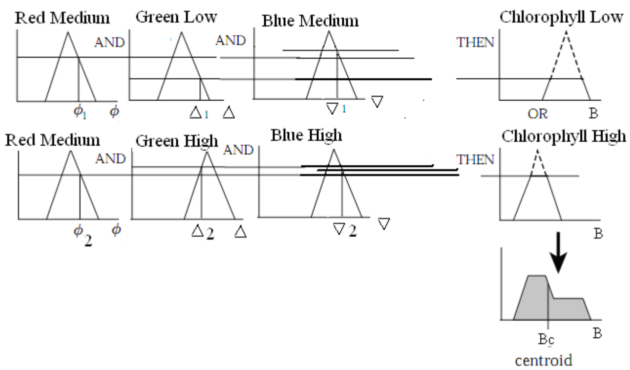

Figure 4. Three rules are combined to produce an output fuzzy set from an input ($\varnothing_1$,Δ_1 , ∇_1). The numerical output of the system is the centroid B_1 of the output set.

Table 4. Mean Absolute Percentage Error in identify of chlorophyll content

Code	Image of soybean leaf			Chlorophyll content		Y_t $-Y'_t$	
	Red	Green	Blue	Actual (Y_t)	Model (Y'_t)		
1	74	89	67	44.2	43.1	1.1	0.02
2	74	94	69	41.4	38.1	3.3	0.07
3	75	90	69	43.3	40.7	2.6	0.06
4	75	93	69	44.8	40.2	4.6	0.10
5	75	92	67	43.3	40.3	3.0	0.06
Sum of Percentage							0.31
Mean Absolute Percentage Error (MAPE)							0.031 = 3,1 %

defuzzification process remains a procedure to calculate the follow value on the centroid production fuzzy established. For analyze of error rate in research use Mean Absolute Percentage Error (MAPE) method in formula2.

$$\mathbf{MAPE} = \frac{1}{n}\sum_{i=1}^{n}\frac{|Y_t - Y'_t|}{Y_t} * 100\% \qquad (4)$$

n : amounts of data
Y't : data from fuzzy calculation
Yt : field data

The harvest of the fuzzy mamdani, remains formerly associated toward the authentic records of chlorophyll content in the ground. It can be understood that the variance among fuzzy mamdani harvest and the authentic chlorophyll content is a lesser amount of than 3,1% standard in table 4.

4. Conclusion

Using fuzzy mamdani into identification of chlorophyll content using image processing technique has been implemented. In this research, it can be demonstrated that the difference of value of chlorophyll content between identification model using fuzzy mamdani and the actual chlorophyll content was less than 3,1 % on average.

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