The Effect of White Balance for Color Constancy on Visible Light

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ABSTRACT

Plant health conditions can be done by calculating the vegetation index. The vegetation index produced by the camera in visible light is more economical than multi spectral or hyper spectral cameras. Image information from visible light cameras will provide an RGB (Red-Green-Blue) value for each pixel to be used to calculate the vegetation index. The RGB value will be greatly influenced by the light conditions (scene) at the time of image acquisition by the camera. Image of plants, will be influenced by the variability of high illumination conditions due to changes in various natural lighting conditions; bright, cloudy, or illuminating nearby objects. To get the right RGB value from each pixel of the image, it is necessary to make adjustments with a certain white balance method. The development of white balance research is also carried out by looking for the value of color constancy. Because the color of the light source, the inherent qualities of the object, and the color of the object's surface will determine the object's color, Color Constancy is performed.. The information generated by the reflectance of light from the surface of a shiny object (reflective) is better than that of a non-shiny object. In this study, experiments were conducted on the effect of the white balance method on color constancy in visible light. The experimental results on the data set processed by the white balance gray world and white patch methods show that there are different RGB values.

CCS CONCEPTS

• **Computing methodologies**; • **Artificial intelligence**; • **Computer vision**; • **Computer vision representations**; • **Image representations**;

KEYWORDS

Vegetation Index, White Balance, Color Constancy, Gray World, White Patch

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1 INTRODUCTION

Agriculture is important to human existence because it is responsible for the production of not only food but also animal feed and bioenergy. The total amount of land in Indonesia that is suitable for agricultural use reached 34,830,062 hectares in the year 2018. This figure takes into account areas of land that are currently unusable for agricultural purposes as a result of natural disasters or other factors. [1]. In 2045, it is estimated that Indonesia's population will have reached 318.96 million, representing a growth of 24.80 percent (63.37 million people) from 2015. This estimate is based on data and population growth projections for the period 2015-2045. The agricultural sector is responsible for ensuring that all people living in Indonesia have access to nutritious and risk-free food at all times. [1], [2]. The Indonesian government has combined the utilization of global technology with the use of ICT infrastructure in an effort to increase agricultural production (Big Data, Internet of Things, Artificial Intelligence and other technologies). Despite the fact that agricultural technology packages are readily available, farmers are unable to implement all of them due to a lack of financial resources, specialized knowledge, and an uneven distribution of activities. Because of this, it is essential for the agricultural industry to make use of technology that is both affordable and simple for farmers to operate [2].

The level of agricultural production can be increased to its full potential if individual plant species' requirements for water, fertilizer, and pesticides are satisfied. The term "precision agriculture" refers to agricultural practices that make an effort to fulfill the requirements of the appropriate plants (PA). The application of PA, which makes use of a number of different technologies, is known as "smart farming." The goal of smart farming is to improve the efficiency of agricultural cultivation processes, cut down on waste, and raise crop yields (SF) [3]–[5]. One possible application of smart farming is one that makes use of a machine learning strategy, as shown in Figure 1.

The utilization of remote sensing (RS) allows for the monitoring of the sufficiency of plant requirements in SF. RS makes frequent use of a wide variety of sensors, some examples of which are multi and hyper spectral cameras, LIDAR sensors, and SAR sensors. The imaging geometry and content of these sensors are vastly different from one another. The fact that each pixel in an RS image corresponds to a spatial coordinate makes it easier to combine the data from individual pixels with data from other sources. The generation of geographic coordinate measures by RS data necessitates the reliability of sensors and the quality of data [6].

The capacity for photosynthesis reveals the degree to which plants are able to fulfill their requirements. The Vegetation Index (VI) is a tool for determining the amount of photosynthetic capacity in a given area. This tool is based on a mathematical equation that

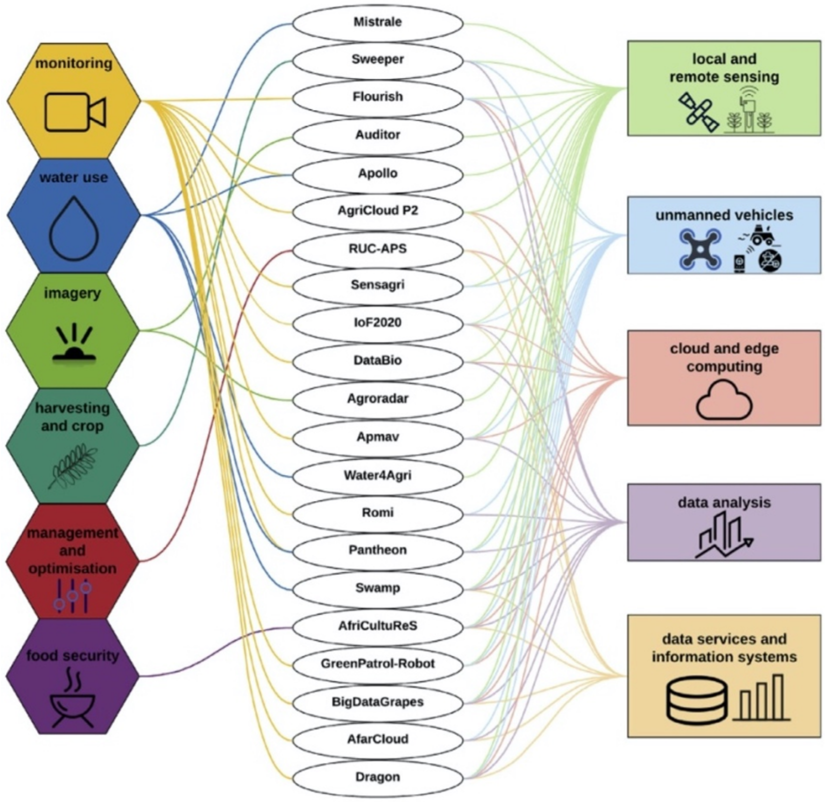

Figure 1: Approaches based on machine learning in precision agriculture [3]

translates a large number of pictures of sensitive plants. [7], [8]. Pearson and Miller (1972) is considered a pioneer in the history of VI because they established two ratio-based indices for the purpose of estimating and monitoring vegetative cover: "Vegetation Ratio Index" (RVI) and "Vegetation Index Number" (VIN) [9]. Rouse et al. introduced the NDVI by making use of MSS data from the United States National Aeronautics and Space Administration's ERTS satellite, which was later renamed Landsat-1. The NDVI is widely used to identify and evaluate the impact of human-caused disturbances such as droughts, fires, floods, and frost. The Normalized Difference Vegetation Index (NDVI) is a tool for monitoring carbon sequestration, regulation of the water cycle, and soil fertility. NDVI measures the photosynthetic activity of plants [8], [10].

The white balance method in a camera is followed by some special nonlinear color manipulation performed by the camera, which makes it difficult to correct the color of the image through post-processing. An efficient white balance method that makes use of the k-nearest neighbor strategy is able to calculate a nonlinear color mapping function to correct image colors in a manner that is both highly effective and broadly applicable [11].

The color of an object can be inferred from the color of the light that illuminates it, the object's inherent properties, and the surface of the object. The ability to measure the color of an object independently of the color of the light source and its description is what we mean when we talk about color constancy [12], [13]. Gray World, also known as GW, is a color constancy method that is very popular. This method asserts that the average reflection of the earth's surface is colorless. The gray edge hypothesis, which asserts that the mean edge difference is achromatic, has emerged as the leading contender for the title of Color Constancy Hypothesis. The method is based on the derived image structure and proposes a framework that combines various methods such as GW, max-RGB, and Minkowski norms with gray-edge and High-Grey-Edge algorithms. The findings indicate that the Color Constancy algorithm that was proposed achieves results that are comparable to those obtained by the most sophisticated Color Constancy method, in addition to having the benefit of being more computationally efficient. For a Lambertian surface, the image valuer, denoted by f = $(R,G,B)^T$, is determined by the light source, denoted by e (λ), where is the wavelength, the surface reflectance, denoted by s (λ), and the camera sensitivity function, denoted by c (λ) [13].

$$c(l) = R(l), G(l), B(l) \tag{1}$$

The absorption of visible light by leaf pigments is the primary contributor to the reflectance spectrum of vegetation in the visible light region (400-700 nm). Chlorophyll a and chlorophyll b are the pigments in plants that are responsible for the selective absorption of blue (400-500 nm) and red (600-700 nm) light, respectively, during the photosynthesis process. The green color of a healthy plant results from the fact that green light (in the range of 500 to 600 nanometers) is absorbed less effectively than other colors. Carotene

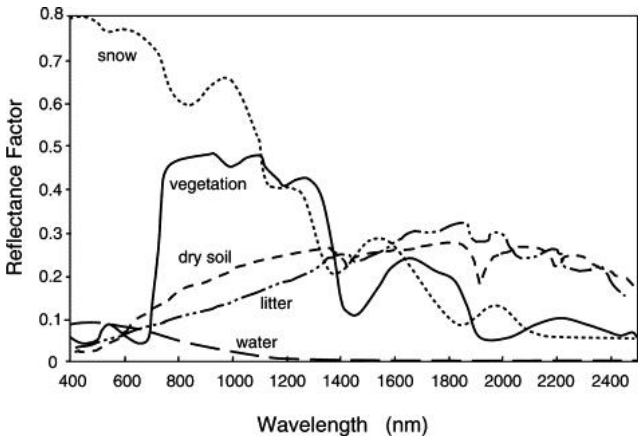

Figure 2: Various Reflection marks are measured based on wavelength and reflectance factor [14].

is a pigment that can range in color from yellow to orange red and is capable of absorbing almost entirely blue light (400-500 nm). In addition, the different hues of fallen leaves can be attributed to the high absorption of red and blue pigments in the range of 400-500 nanometers, which is found in the leaf. [14].

According to the findings of studies conducted on the ideal method of reflectance, it is known that objects that reflect light effectively produce good reflectance information [15]. The amount of light that is reflected or the amount of light that is present in digital images can be determined using a variety of color spaces, each of which is a mathematical representation of a specific color set. The RGB data that is produced by various devices, such as cameras and scanners, is used in the construction of color spaces. RGB is by far the most popular color space for use with digital images. This is due to the fact that any color can be produced by combining red, green, and blue screens [16].

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Figure 3 depicts the reflectance spectrum of plants with visible (VIS) and near infrared (NIR) absorption features captured by the ImSpector PFD V10E hyperspectral camera and short wave infrared (SWIR) captured by the ImSpector N25E hyperspectral camera. [19]. By altering the spatial spectrum, diffuse reflection coefficient, and specular reflection exponent (sheen) of the image Phong illumination model, the surface reflectance properties of the image pattern under surface deformation were investigated [20]. The consistent mistake pattern and response variability suggest that the subject's evaluation is based on the similarity of the surface image's brightness histogram [21].

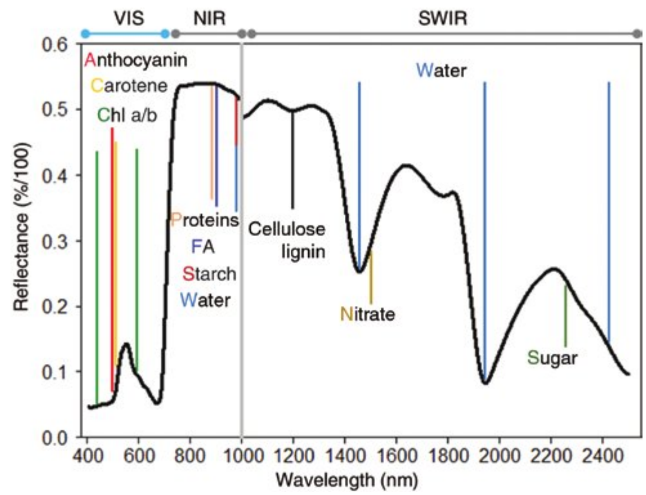

Figure 3: Characteristics of the reflectance spectrum of plants with compound absorption features [19]

Table 1: Ground Truth Dataset Characteristics

No	Description	Values
1	*Bit per Sample (RGB)*	8 8 8
2	*Image Length (pixel)*	1124
3	*Image Width (pixel)*	749
4	*X Resolution (dot per inch)*	300
5	*Y Resolution (dot per inch)*	300

1.1 Data Collection and Characteristics

This investigation was carried out to determine how important white balance is for maintaining color consistency in visible light. A picture of a plant that has a color chart superimposed on it is the required data set. The data sets that are compatible with the criteria were obtained from previous studies and are stored at https://github.com/mahmoudnafifi/WB_sRGB/tree/master/examples_from_datasets/RenderedWB_Set1. The image that is being used consists of a reference image (ground truth) that will be used as a measurement reference and an input image that will try to be processed using two different white balance methods. Both of these images will be used as a measurement reference. The characteristics of the ground truth data set that was utilized have the characteristics that are described in Table 1.

2 EXPERIMENTAL STAGE

The stages of research carried out broadly start from preparing a data set consisting of a reference image (ground truth) and an input image. The ground truth image is stored as a reference value, while the input image will be converted using the white balance white patch method and the white balance GW method. The next step is to calculate the RGB value of each color chart color box in each image (ground truth and input image converted using the white balance white-patch and GW method). After obtaining the RGB values from each color box, a comparison between the input RGB

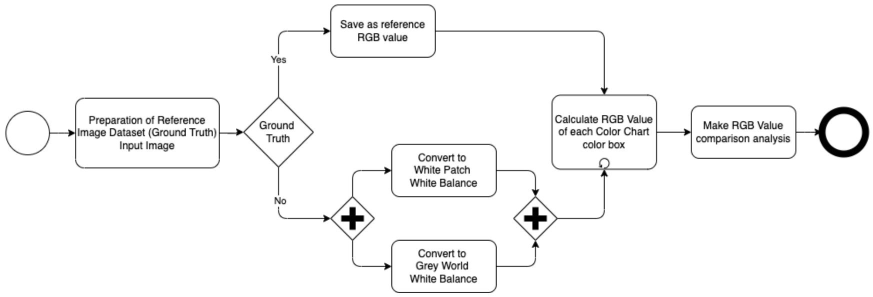

Figure 4: Experimental Stage

Figure 5: Experimental results

values and the RGB ground truth values is performed for analysis. Figure 4 displays the phases of this investigation..
Details of the detailed research stages carried out are as follows:

- Get an image of a plant that has a color chart consisting of a reference image (ground truth) and an input image, obtained from previous research.
- To facilitate the experimental process, in this study a computer application was made using the Python programming language.
- The ground truth image is read using the imread() function from openCV, and stored as a reference value in this experiment.
- The input image is read using the imread() function from openCV, and stored in the input image variable, then modified using the white balance gray-world method, and the white balance white-patch method.
- Calculate the RGB value of each color box (element) of the color chart.
- Make an analysis of the obtained RGB values and compare them with the RGB values of the ground truth image.
- Analyze the RGB values obtained by displaying the MSE value and the mean of the input image processed using the white balance gray-world and white balance white-patch methods.

3 RESULT AND DISCUSSION

After carrying out the experiment in accordance with the stages of the research design, the findings obtained were visualized in the form of the reference image and the modified input image using the two different methods of white balance. The white balance white-patch method produces a brighter image, whereas the gray-world white balance method is more faithful to the color intensity of the ground truth image. This can be seen when making a side-by-side comparison of the two approaches.
OpenCV functions written in the programming language python are used to display the results of data processing carried out on each image. These findings are presented in the form of RGB values that were extracted from the images. Figure 6 displays the evaluation results of the study for the color chart components [1, 1], while Figure 7 displays the evaluation results for the entirety of the color chart components.
It is possible to perform an analysis on the RGB value of each image to determine how significantly it deviates from the RGB value of the ground truth image. According to the findings of the investigation, which are outlined in Table 2, it has been determined that the RGB value obtained using the GW method is more comparable to the RGB value obtained using the white patch method.
The results of this experiment lend credence to the Color Constancy method, which operates under the presumption that the typical

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Elemen ColorChart [1,1] pada Koordinat:[ 1, 1]
------------------------------------------------
      Ground Truth | Grey World | White Patch
------------------------------------------------
Blue :      33     |     45     |     51
Green:      42     |     37     |     49
Red  :      62     |     55     |     66
------------------------------------------------
MSE  :             |   218.9397|    405.3904
------------------------------------------------
Mean
Ground Truth : [33.42, 42.26, 62.09,  0.00]
Grey World   : [45.58, 37.16, 55.42,  0.00]
White Patch  : [51.58, 49.38, 66.97,  0.00]
------------------------------------------------
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Figure 6: Evaluation Results of Color Chart Elements [1, 1]

IDLE Shell 3.10.4

No	Ground Truth B-G-R			Ground Truth Mean[B-G-R]			Grey World B-G-R			Grey World Mean[B-G-R]			Grey World MSE	Grey World PSNR	White Patch B-G-R			White Patch Mean[B-G-R]			White Patch MSE	White Patch PSNR
0	33	42	62	33	42	62	45	37	55	45	37	55	0.00	29.50	51	49	66	51	49	66	0.00	26.82
1	87	98	134	88	99	135	122	88	128	124	89	129	0.01	21.44	138	117	154	140	118	156	0.02	17.49
2	106	86	64	107	86	64	165	77	57	167	77	57	0.02	17.18	186	101	69	188	102	69	0.04	14.54
3	32	67	60	31	67	59	52	61	45	51	60	44	0.00	24.66	59	81	55	58	80	54	0.00	23.16
4	136	98	92	135	97	92	201	88	94	201	87	93	0.02	16.44	226	117	113	226	115	112	0.05	13.37
5	132	148	95	132	148	96	181	139	63	181	139	63	0.02	17.41	204	184	76	204	185	76	0.04	14.54
6	19	69	140	18	68	139	39	61	134	39	61	133	0.00	25.91	44	81	161	44	82	161	0.01	21.77
7	119	61	44	121	62	44	182	51	53	186	52	55	0.02	16.47	205	67	65	209	69	66	0.04	13.70
8	64	52	125	65	51	126	70	39	125	71	39	126	0.00	29.95	79	52	150	80	52	151	0.00	23.31
9	62	35	51	62	35	50	79	29	51	79	29	51	0.00	27.38	89	39	62	89	39	62	0.00	23.23
10	42	137	125	42	137	125	70	130	96	69	130	95	0.01	20.69	79	171	116	78	172	115	0.01	18.62
11	14	107	162	16	106	161	53	104	151	53	103	151	0.01	21.11	60	137	182	60	136	182	0.02	17.78
12	91	42	14	90	41	13	133	32	32	134	33	32	0.01	19.14	150	43	39	150	44	39	0.02	16.49
13	40	100	63	41	99	62	70	101	34	70	100	34	0.01	20.75	79	133	41	79	132	41	0.02	18.11
14	36	32	104	35	32	104	34	24	102	34	24	102	0.00	34.08	39	32	123	39	32	123	0.00	27.47
15	19	143	179	20	143	178	58	138	160	57	137	160	0.01	20.47	66	183	193	65	182	193	0.02	17.13
16	112	62	123	111	61	122	141	47	135	140	45	134	0.01	21.90	158	62	163	157	60	161	0.02	17.23
17	123	98	39	121	96	37	201	91	0	198	90	0	0.04	14.17	226	121	0	223	119	0	0.06	11.97
18	179	181	181	170	172	172	222	164	174	212	157	165	0.01	19.72	250	217	210	239	208	200	0.04	14.54
19	152	152	152	152	152	152	201	137	136	202	138	136	0.02	18.19	226	181	164	227	183	164	0.03	14.66
20	116	117	116	116	116	115	168	105	98	168	105	98	0.02	17.85	189	138	119	189	138	119	0.03	15.17
21	78	79	79	78	78	79	114	69	65	115	69	65	0.01	20.73	129	91	79	130	92	79	0.01	18.30
22	50	49	48	49	48	48	72	43	40	72	43	39	0.00	24.96	81	57	48	81	57	48	0.01	22.53
23	24	24	23	23	23	23	38	25	26	37	25	25	0.00	29.81	43	33	32	42	33	31	0.00	25.69

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Ln: 67 Col: 0

Figure 7: Evaluation Results of Color Chart for all Elements

Table 2: Analysis of the deviation of RGB color channel values

Color Channel	*Ground Truth*	*Gray World*		*White Patch*	
		Result	Deviation	Result	Deviation
Blue	33	45	12	51	18
Green	42	37	-5	49	7
Red	62	55	-7	66	4

reflection of the earth's surface is colorless and, as a result, advises the use of a GW white balance [13].

4 CONCLUSION

Experiments will be carried out in order to determine the appropriate color space for the application of plant images by taking into account the intensity of the light. This will be the subject of additional research that will be carried out. This is evidenced by the high Mean Square Error (MSE) value, even though the gray-world method (GWM) is smaller than the white-patch method. From the MSE value for the GWM which is smaller than the white-patch method, it is stated that the GWM is closer to the ground-truth reference image.

In light of the results of the experiment, there are a number of considerations that need to be given attention to, including the ones that are listed below:

1. A smaller MSE value indicates that the tested image is close to the ground-truth reference image.

- It is necessary to carry out further experiments by analyzing the tendency of white balance on color chart elements to see the tendency of accuracy to certain colors.

5 FUTURE WORKS

Experiments will be carried out in order to determine the appropriate color space for the application of plant images by taking into account the intensity of the light. There will be more research done in the future. In the not too distant future, there is going to be research done on the consistency of leaf color and the influence of light reflection. Because photosynthesis cannot occur unless the leaves reflect light in all of its wavelengths, light reflection is one of the most important factors to take into account. Light reflection is visible in the intensity channel, which is one of several types of color space distinct from the color channel and the saturation channel. As a part of the ongoing investigation that we are conducting, we are going to make use of the camera on the UAV to take pictures of a variety of plants so that we can evaluate the results in light of those of earlier studies.

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