

Bell Pepper And Chili Pepper Classification: An Application Of Image Processing And Fuzzy Logic

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Abstract: Bell pepper is often called sweet pepper and capsicum in other countries. Peppers are well-known for their different colors and uses. Capsicum peppers contain abundant antioxidants and vitamin C. In comparison to red peppers, it has nine times the level of carotene, such as lycopene which is claimed to improved heart health and reduce cancer risk. While, chili pepper, better known as "Siling Labuyo" in the Philippines, is the fruit from the Genus capsicum plant, a member of the nightshade family, Solanaceae. These two kinds of pepper are commonly used as an ingredient for a different type of foods in the Philippines. Bell pepper is typically used in Filipino recipes to enhance its flavor and makes it smell better, while chili peppers are used to enhance the spiciness of the food. In this paper, the methods to be used in classifying differences of the seeds of bell pepper and chili pepper are image processing, fuzzy logic and K nearest neighbor. The morphological features of the seeds such as area, equivalent diameter, perimeter, and roundness in the gathered data from 60 samples of bell pepper and chili pepper seeds have been analyzed to classify bell pepper and chili pepper's seeds characteristics. The fuzzy logic has been employed to determine the degrees of truth between truth and false instead of the common that only identifies truth and false. MATLAB toolbox will be utilized for the study. The areas, equivalent diameter, perimeter, and roundness will be used as inputs to Mamdai Fuzzy interference to formulate rules and come up to an output that will classify whether the seeds are bell pepper or chili pepper.

Index Terms: Bell pepper, chili pepper, fuzzy interference, fuzzy logic, image processing, K nearest neighbor, Matlab

1. INTRODUCTION

Bell peppers are fruits with a beautiful shape and different colors varying from green, red, yellow, orange, purple, brown to black [1]–[4]. Even though they have different colors, they are all the same kind of plant known as *Capsicum annum*. It is famous for its health content [5]. It contains vitamin C, which improves the immune system, prevents infections, increases the growth and repair of tissue, and helps in avoiding cancer [6]. It also has vitamin A that is good in improving eyesight, enhancing the lung function, and likewise enhances the immune system [7]. Furthermore, it contains nutrients that prevent prostate and breast cancer such as Lycopene, and nutrients that prevent cataracts and muscle degeneration such as lutein and zeaxanthin [8]. On the other hand, chili pepper, are one of the very popular spices known for its medicinal and health benefiting properties despite their fiery hotness [9]. It is considered one of the most important commercial spice crops [10]. Sampling and testing of seed observe standard procedures. These procedures are made by ISTA to assess seeds going in international trade [11]. In this study image processing and fuzzy logic were used for the identification of bell pepper and chili pepper. After extracting the features of the sample seeds, it will undergo an intelligent recognition algorithm applying fuzzy logic. Fuzzy logic identifies the degrees of truth instead of the common that only identify completely truth and completely false [12]. diabetes and other diseases which will minimize their expenses.

2 FEATURE EXTRACTION

After capturing the samples, bell pepper and chili pepper classification undergo through five steps namely; pre-processing, image segmentation, feature extraction which then undergo the fuzzy logic algorithm to recognize and classify the bell pepper accordingly [13], [14].

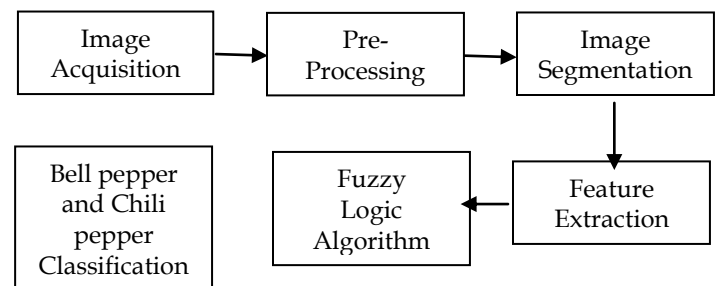


Fig 1. Block Diagram of the Bell pepper classification system

2.1 Digital Image Scanning

Each image used has at least 30 samples of seeds because seeds do not contain a large area and place the samples in a bond paper. A light was placed underneath the bond paper to remove the shadow of the seeds and lessen its noise. And also, it will be helpful in improving the accuracy of the morphology features [15]. The camera used has 16 megapixels and is placed 5 inches above the seeds. Figure 2 and 3 below shows the original image of the bell pepper seeds and chili pepper seeds.

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Fig 2. Original Image of bell pepper seeds

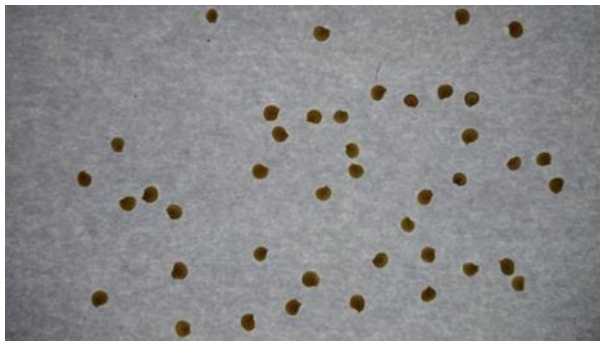


Fig 3. Original Image of chili pepper seeds

2.2 Preprocessing

By using MATLAB Version 2012a, the original image of bell pepper seeds and chili pepper seeds were converted to grayscale and again converted to binary to be used in the binarization of the original image on image segmentation. Figure 4 and 5 shows the outcome of the two images after applying `rgb2gray`.

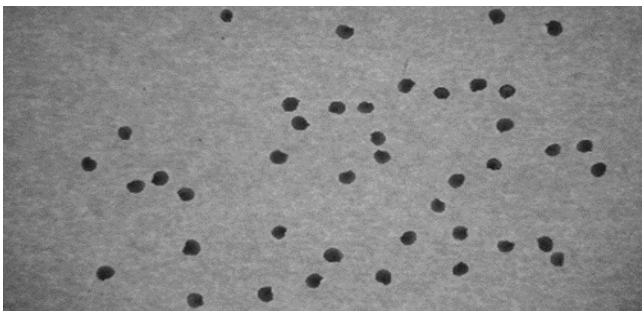


Fig 4. Grayscale version of bell pepper

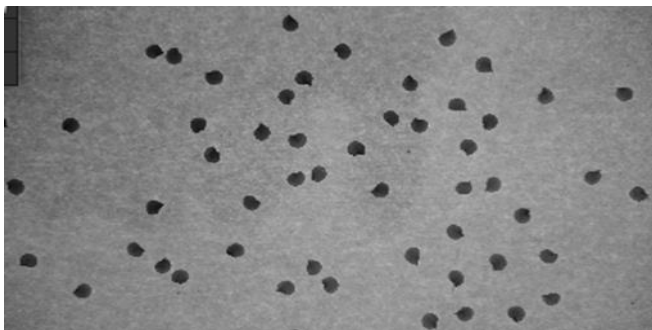


Fig 5. Grayscale version of chili pepper

2.3 Image Segmentation

The mask is a matrix that contains 0 and 1 values and the original images of the bell pepper are binary or in gray level [12]. Figure 6 shows the raw segmented image with fewer noises. Just by adjusting the code "`c=220-b`" using trial and error, it minimizes the noise in the image. The image is filtered first for enhancing and removing the noises and unwanted spots using Matlab function, `bwareaopen`. Using the code, "`z=bwareaopen (f,5000);`" the segmented image is filtered. Figure 7 shows that the only classified image is the seeds.

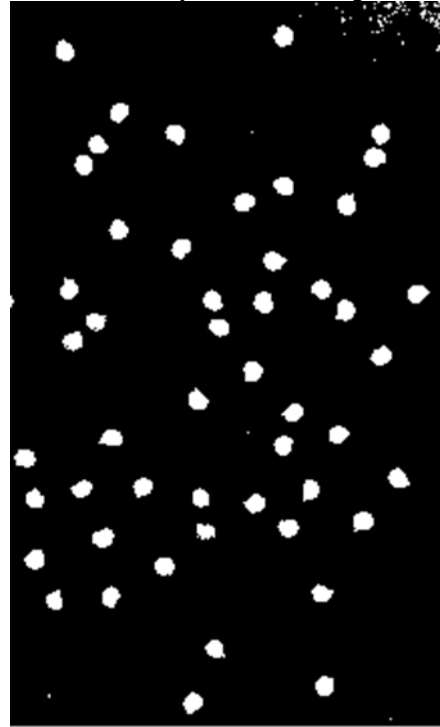


Fig 6. Segmentation of the Original Image

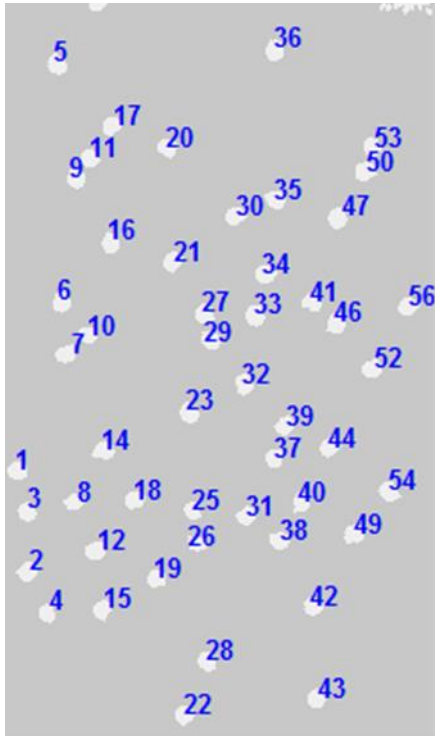


Fig 7. Filtering and Identification of the Original Image

2.4 Feature Extraction

The most critical stage in the classification task is feature extraction[16]. Feature extraction traces the boundaries of holes inside the seeds and exterior boundaries of seeds in binary images. Roundness, area, perimeter, and equivalent diameter are the chosen parameters that undergo the fuzzy logic algorithm on the next step. The perimeter was not included since its significance is very low.

3 FUZZY LOGIC ALGORITHM

The numbering for sections is two Arabic numerals that are separated by periods, as shown in this paper. The initial, introductory paragraph is the only one with a drop cap, and after the section title, the first paragraphs have no indent.

3.1 Fuzzy Logic Controller

Describing a fuzzy set is a base for designing a Fuzzy Logic System that is close to a human thinking logic. A fuzzy set may be considered as an extension of the classical set. Crisp set theory only complies with a membership element that takes only a defined 0 or 1 value, a binary logic. However, on the fuzzy set theory, it contains a gradual or changing degree of membership in a set. It does not completely belong to a set but is in between. It is only defined by a boundary which makes the degree of membership of an element to range only in between from 0 to 1. Hence, a fuzzy set does not have a crisp or exact and defined boundary[17]–[19].

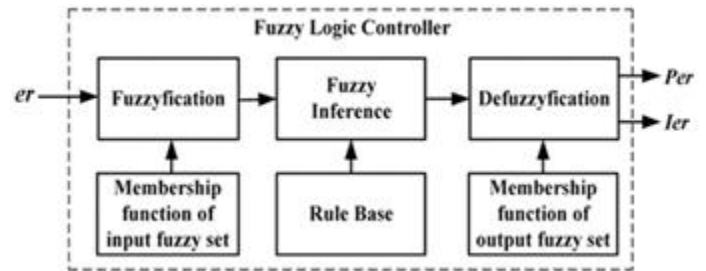


Fig 8. Block Diagram of Fuzzy Logic Controller

3.2 Control Objectives Description

Area, equivalent diameter, perimeter, and roundness will serve as the input variable of the fuzzy logic algorithm while Bell pepper and Chili pepper Classification (BCC) will serve as the output. Due to the small results of feature extraction, the perimeter can be ignored and not included in the study.

3.3 Deciding the Input and Output Variables

The corresponding variables listed above are the input as well as the output utilized in a fuzzy logic algorithm.

Area: will be determined using membership functions "small, medium, large"

Equivalent diameter: will be determined using membership functions "small, medium, large"

Perimeter: will be determined using membership functions "small, medium, large"

Roundness: will be determined using membership functions "small, medium, large"

BCC: will be determined using membership functions "bell pepper and chili pepper"

3.4 Membership Function

Figure 9 shows the Gaussian membership function, where the results from the rule structure were used for the input parameter- area, triangular membership function was used and analyze on the equivalent diameter and another triangular membership function for roundness [20].

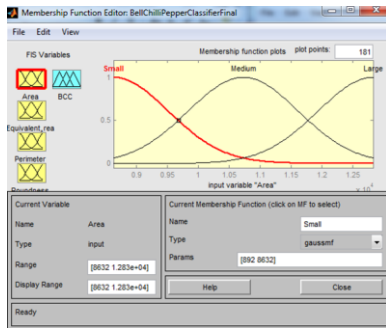


Fig 9: Membership Function for Area

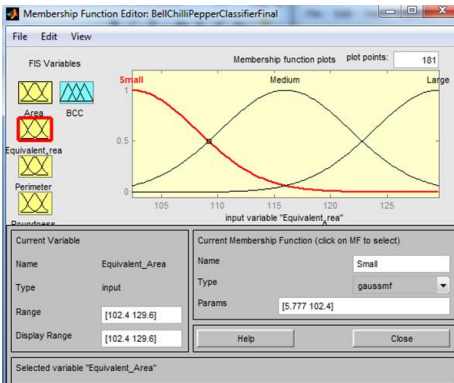


Fig 10: Membership Function for Equivalent Diameter

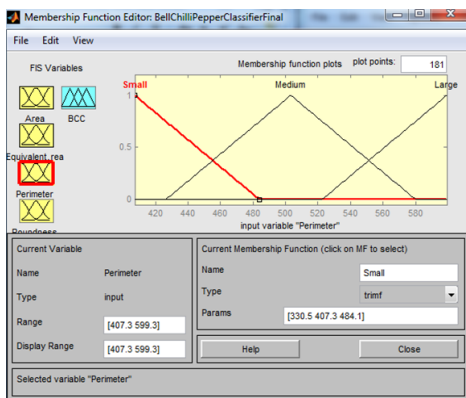


Fig 12: Membership Function for Roundness

3.5 Output Response

The output response “BCC” which means Bell pepper and Chili pepper Classification is shown in the membership function editor. As the result is nearer to 0 it means that the classified seed is chili pepper while as the output is closer to 1, it means that the seed is bell pepper.

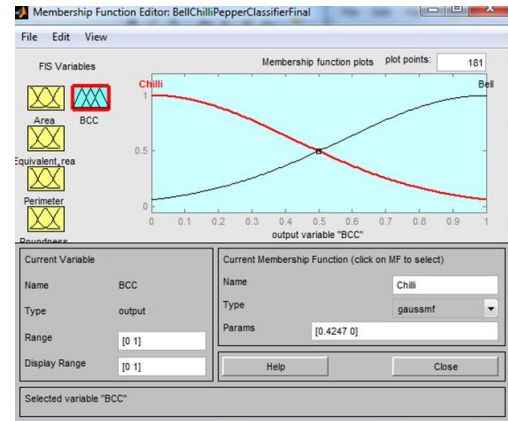


Fig 13: Membership Function for the Output Response

3.6 Formulation of Fuzzy Rules

There is a total of 81 rules that were made based on the given parameters; area, equivalent diameter, perimeter, and roundness. It fitted the data on the table which shows its accuracy. The certain condition will fall under these rules.

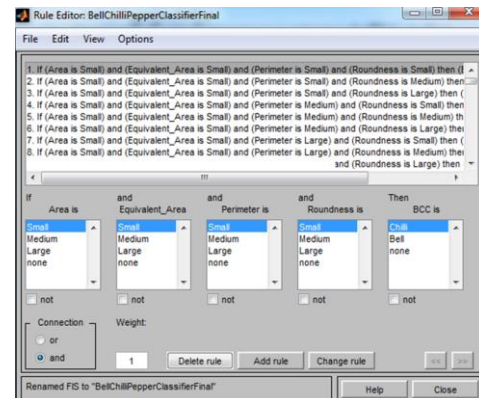


Fig 14: Rule Editor for the Bell pepper and Chili pepper Classifier

3.7 Surface Evaluation

With the utilization and aid of the Surface Viewer, one of the building systems with the fuzzy logic toolbox that is dynamically linked to the FIS, one may grab the axes and reposition them to be able to get a different three-dimensional view on data [21]. Surface Viewer is also capable of working with cases with two or more inputs and one output. The reference input field was used when more inputs are required by the system than the surface mapping.

Figure 15 shows the resulting output in the Surface Viewer and its input.

4 RESULTS AND ANALYSIS

4.1 Morphological Feature Extraction

A total of 120 seeds samples, 60 samples on each were listed in table 1.

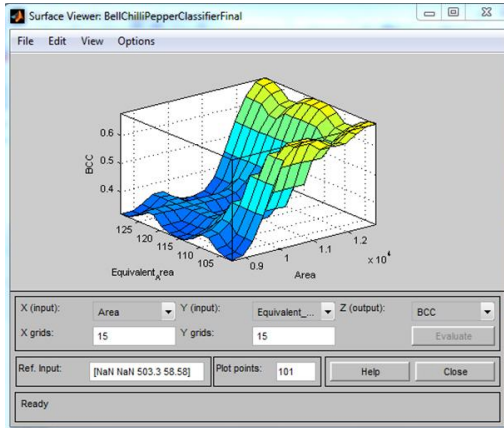


Fig 15: FIS Surface View

51	9211	108.295	421.8603	65.03997	51	10269	114.3455	592.725	36.73098
52	9440	109.6329	429.9357	64.17647	52	10778	117.1451	496.8011	54.87619
53	9960	112.612	442.2387	63.99657	53	12673	127.0266	490.1148	66.29712
54	8761	105.6165	412.685	64.64385	54	9707	105.2905	484.8011	46.55349
55	10147	113.6642	459.8729	60.29383	55	9230	102.3658	473.2864	46.1703
56	11269	119.7837	501.6869	56.26402	56	10470	115.4592	502.7006	52.06415
57	10628	116.3271	487.3924	56.22182	57	9749	111.4128	456.8011	58.71062
58	8228	102.3534	411.4804	61.06704	58	10328	114.6735	523.4285	47.37098
59	10940	118.0222	482.7295	58.99572	59	10615	116.2559	508.9432	51.49822
60	10099	113.3951	479.8304	55.12057	60	10263	114.3121	538.7422	44.4348

Chili pepper Seeds	Area	Equivalent Diameter	Perimeter	Roundness	Bell pepper Seeds	Area	Equivalent Diameter	Perimeter	Roundness
1	11107	118.9196	440.5168	71.92547	1	12833	127.826	580.5828	47.84216
2	11538	121.2049	439.2447	75.14989	2	11242	119.6401	487.4285	59.46106
3	11170	119.2564	446.4163	70.43426	3	12493	126.1213	550.8843	51.73171
4	10294	114.4846	376.7178	71.15128	4	11344	120.1817	480.2569	61.80589
5	10042	113.0746	488.3158	52.92118	5	11375	120.3458	464.7595	66.1768
6	9758	111.4642	412.4752	72.07357	6	10667	116.5403	440.5168	69.07617
7	8479	103.9028	407.3036	64.2272	7	12818	127.7513	527.7716	57.82813
8	11140	119.0961	444.8011	70.75618	8	11528	121.1524	496.6001	58.74234
9	9661	110.9088	480.6589	52.54834	9	11378	120.3616	611.5534	38.23033
10	8671	105.0726	412.9205	63.90682	10	12318	125.2348	511.2864	59.21375
11	10899	117.8008	425.8894	75.5099	11	11376	120.351	498.6589	57.49013
12	10874	117.6657	535.9138	47.57845	12	13185	129.5672	548.8427	55.00412
13	8793	105.8092	448.4163	54.95221	13	12251	124.8938	498.4579	61.962
14	9090	107.5814	461.9727	53.52321	14	11286	119.874	462.7595	66.22779
15	9530	110.1543	501.3869	47.63847	15	12188	124.5722	557.9554	49.19765
16	8452	103.7373	536.6417	36.8809	16	12113	124.1884	485.9727	64.45236
17	9702	111.1439	394.2325	78.44537	17	13560	131.3968	592.0975	48.60535
18	10753	117.0092	599.2691	37.62675	18	11955	123.3758	535.2275	52.44253
19	10144	113.6474	492.4579	52.56321	19	11564	121.3414	518.7006	54.0114
20	8017	101.0325	497.1859	40.7554	20	11936	123.2777	508.2153	58.07299
21	10489	115.5639	451.2031	64.74419	21	11867	122.9208	472.0732	66.91649
22	9514	110.0618	486.7006	50.47197	22	11053	118.6302	491.8721	57.40988
23	11364	120.2875	480.4579	61.86306	23	11304	119.9696	504.2153	55.87416
24	10132	113.5802	463.3869	59.29507	24	11479	120.8947	516.2569	54.12317
25	10747	116.9765	438.4163	70.26269	25	12523	126.2726	542.6417	53.44326
26	10154	113.7034	473.73	56.8573	26	10965	118.157	500.9432	54.90887
27	8411	103.4854	468.3158	48.19266	27	12437	125.8383	538.5412	53.88758
28	8664	105.0302	472.8024	48.7046	28	12351	125.4025	539.9138	53.2432
29	9983	112.742	425.7921	69.19532	29	12804	127.6815	596.8255	45.17122
30	9996	112.8153	482.9582	53.85401	30	10611	116.234	506.4579	51.98529
31	11665	121.8702	502.5824	58.03381	31	10804	117.2863	527.6711	48.76058
32	12592	126.62	510.5285	60.71075	32	9893	112.2326	471.9727	55.80911
33	9009	107.101	463.8293	52.62246	33	9971	106.8748	449.73	55.73757
34	11583	121.4411	498.6204	58.54528	34	10654	116.4693	458.5584	63.66991
35	9086	107.5577	470.2159	51.64033	35	10583	116.0806	441.5879	68.20015
36	9411	109.4644	482.9678	50.70027	36	10221	114.078	476.2325	90.73851
37	11885	123.014	500.2431	59.68262	37	9485	109.8939	485.6295	50.54033
38	10920	117.9143	489.7294	57.21648	38	10389	115.0117	439.2031	67.67898
39	10391	115.0227	480.4201	56.57517	39	9256	108.5592	514.2569	43.9819
40	10785	117.1831	482.7504	58.15482	40	9574	110.4083	482.0143	51.78267
41	11109	118.9303	491.551	57.77616	41	11398	120.4674	484.8011	60.94139
42	10531	115.795	471.9759	59.40744	42	10797	117.2483	439.1026	70.36909
43	10293	114.4791	456.9286	61.95212	43	10607	116.2121	510.2153	51.20313
44	9987	112.7645	420.9562	70.82264	44	9984	112.7476	516.9432	46.94937
45	8632	104.8361	413.8662	63.32897	45	10209	114.011	430.7595	69.1392
46	11454	120.7629	495.0285	58.73644	46	10017	112.9338	533.2275	44.27142
47	9871	112.1077	439.6932	64.16121	47	9928	112.431	570.2986	38.35907
48	9002	107.0593	430.6825	60.98674	48	10267	114.3344	514.9432	48.65593
49	11145	119.1229	496.9247	56.71655	49	10386	114.9951	403.2031	80.28076
50	11208	119.4591	446.483	70.65276	50	10610	116.2285	581.6539	39.40914

By the data gathered above, the range of the extracted features from bell pepper and chili pepper was shown in Table 2. This data is the basis for the development of the membership function on the fuzzy logic algorithm.

TABLE 2

Ranges of features extracted from 120 seeds of bell pepper and chili pepper

Type of Pepper	Area	Equivalent Diameter	Perimeter	Roundness
Chili pepper	8471 to 11856	101.0257 to 121.8193	407.3036 to 599.2691	36.8809 to 75.14989
Bell pepper	9256 to 13185	114.078 to 129.5672	449.73 to 596.8255	43.9819 to 80.28076

4.2 Inference Method

In Mamdani inference, the consequent of If-Then rule is defined by the fuzzy set [22]. The output fuzzy set of each rule will be reshaped by a matching number, and defuzzification is required after aggregating all of these reshaped fuzzy sets [23].

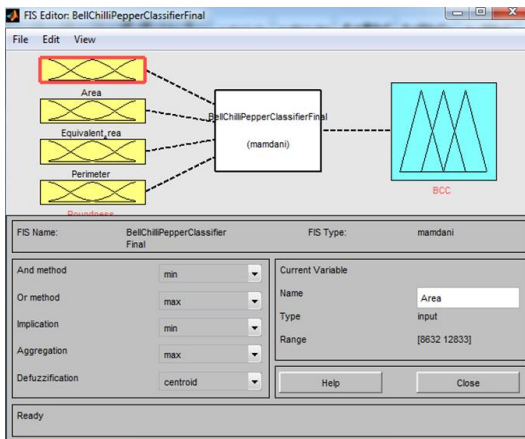


Fig16 FIS Editor

4.3 Defuzzification

Defuzzification is the process of calculating the fuzzy model sets and corresponding membership degrees through a precise numerical value, hence, in a crisp logic results [24]. Defuzzification is usually utilized in a fuzzy control systems [25]. In accordance with that, a set of rules is required to transform various variables into a fuzzy result. The results are to be described accordingly to the terms of membership function in the set of fuzzy logic [26]. Figure 14 shows the rule viewer of the bell pepper and chili pepper classifier. Based on the simulation, it has been verified that at $1.07e+04$ area, 116 equivalent diameter, 503 perimeters, and 58.6 roundness, the output response is 0.321 which is closer to 0. Therefore, the sample is a Chili pepper.

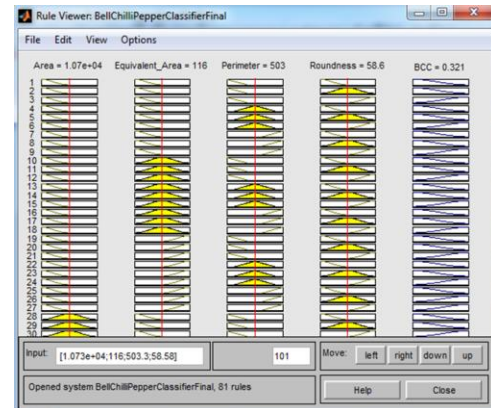


Fig 17 Rule Viewer

By the use of the data gathered from four-parameter: area, equivalent diameter, perimeter, and roundness, the researcher can now classify the bell pepper and chili pepper through fuzzy logic. It shows that the accuracy rate of fuzzy logic is 85% based on the results obtained above.

6 CONCLUSION

In this study of Classification of bell pepper and chili pepper through seeds, image processing, and fuzzy logic. The process of Feature extraction and the fuzzy logic algorithm is based on the data gathered in the bell pepper's seeds. The simulation shows the accuracy of the algorithm that can be used to fully recognize the difference between the chili and bell pepper.

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