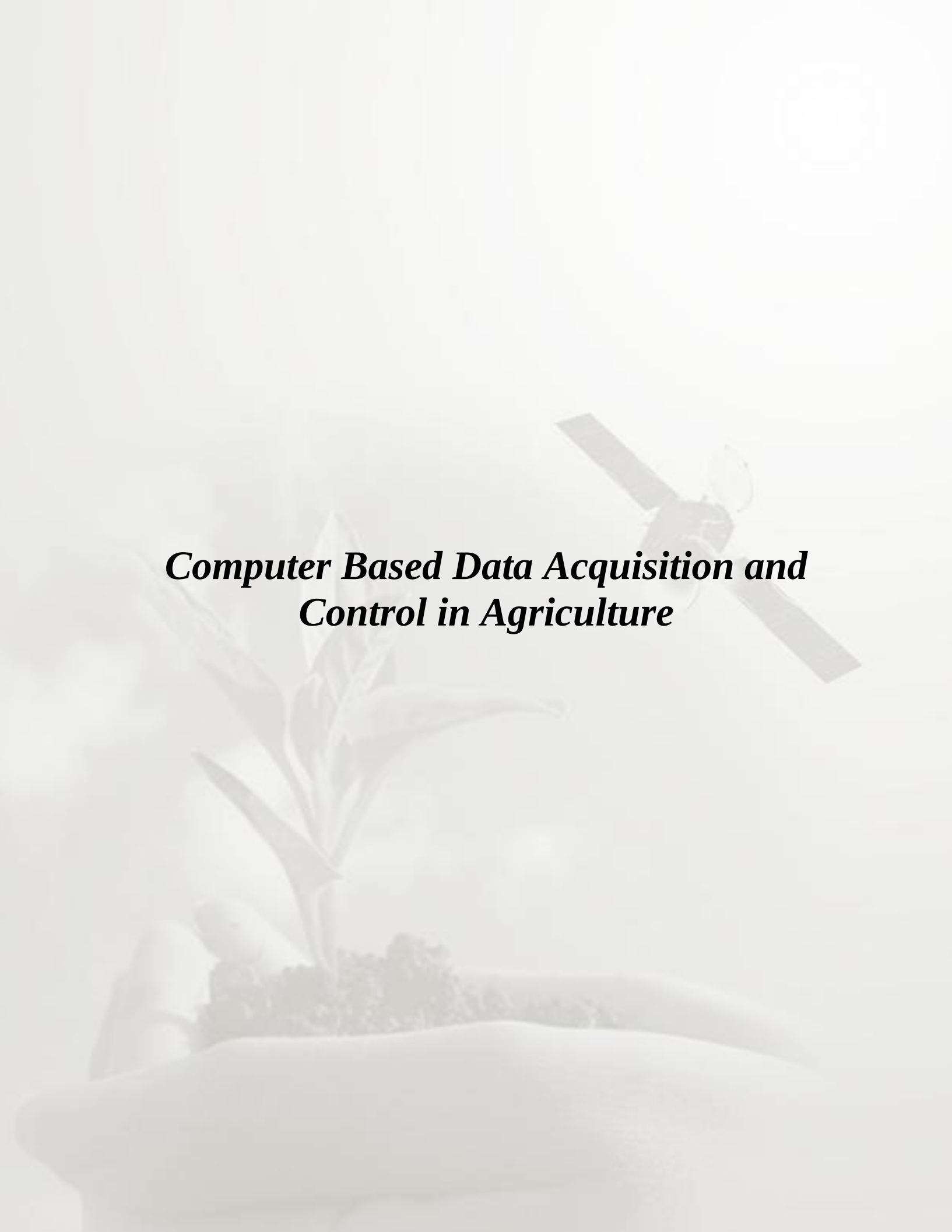

Computer Based Data Acquisition and Control in Agriculture

Determination of Cocoa Bean Quality with Image Processing and Artificial Neural Network

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ABSTRACT

The objective of this research was to determine the quality of cocoa beans through their digital images. Samples of cocoa beans were scattered on a bright red paper under a controlled lighting condition. A compact digital camera was used to capture the images. The images were then processed to extract their shape and color parameters. Two ANN structures were then used to develop the relationship between input parameters and the bean's quality components and the outputs. The first ANN having 35 input nodes, classified the bean into 4 beans sizes: whole beans, broken beans, bean fractions, and skin damaged beans. The prediction accuracies were 84%, 52%, 20%, and 20% respectively for the four classes. The low accuracies were caused by the wide variety of beans shapes. The second ANN structure used 6 color parameters to classify the beans into 3 types: normal fermented beans, non fermented beans, and beans with mold. The prediction accuracies were fairly good: 99%, 98%, 79% respectively for the four classes.

Keywords : *cocoa quality, image processing, ANN*

Introduction

The quality of Indonesian cocoa bean, especially at farmer level is relatively low. Farmers are not encouraged to maintain their cocoa bean quality because purchasing price by local traders almost neglecting the bean quality. Fermenting the beans, as one effort to increase bean price, is not appreciated by traders with appropriate price. As the results, farmers do not handle the beans in proper post harvest practice or sell the beans in wet condition. As an effort in improving cocoa beans quality, a bean quality classification method is required. Besides the existing quality classification method, there are other possible methods can be used. As bean classification can be done by human eyes, so there is possibilities to imitate the work of human ice with an image based classification method. This research aimed at exploring the possibility to use image processing technique to do the quality classification. This paper reports two separated similar researches which tried to classify different components of cacao beans quality parameters. Both research used the same instruments and the same approach, so it can be reported in one paper.

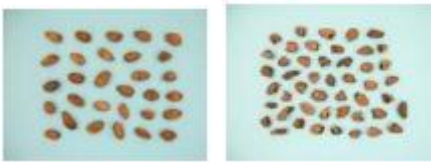
Materials and Methods

This research was done from March – August 2004. Cocoa beans were collected from Rajamandala Plantation, West Java and Coffee and Cacao Research Center, Jember, East

Java. Tools and instruments used in this research were a digital camera, a set of computer, and an image capturing space under a controlled lighting condition as shown in Figure 1.

Figure 1 The light-controlable image capturing chamber

For sample background, a light blue paper were used in order to give a contrast different between sample and the background. This color were found by trial and error. Before image capturing, the bean samples were classified in proper way, by using sieves and manual eye inspection so that they could be used as the references. Two kinds of classification were done in this research: bean breakage (whole beans, broken bean, bean fraction, and damaged bean) and bean fermentation status (fermented beans, non fermented beans, and moldy beans). For the purposed sets of samples were prepared: 522 whole beans, 203 broken beans, 387 bean fractions, 133 damaged beans, 512 fermented beans, 436 moldy beans, and 53 non fermented beans.



a. Whole Beans b. Broken Beans

c. Bean Fractions d. Skin Damaged Beans

Types of beans breackage

a. Fermented Beans b.Beans with Mold

c. Non Fermented Beans

Types of bean fermentatiaon status

The images were then processed with Visual Basic programs in order to extract their shape and color components. The programs toke the image of every bean and calculate its individual shape and color characteristics. The characteristics were then saved in a text file for ANN training purpose.

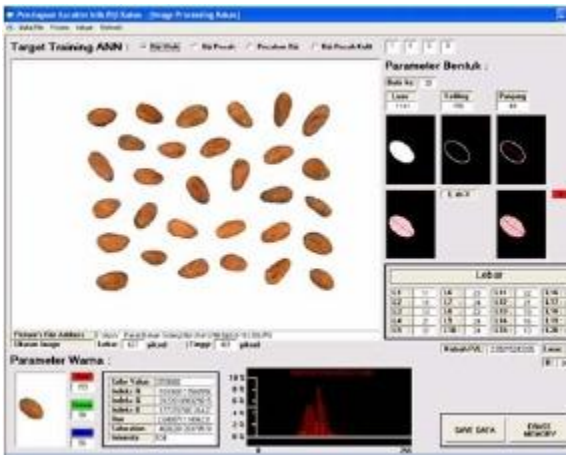


Image processing software

Two ANN structures were develop for the two classifications as shown in Figure 4. The first structure was for classifying beans breakage and the second for classifying fermentation status. The input nodes for the first ANN was area, perimeter, length, 20 segments of width, R, G, B, H, S, I, color component indexes, and roundness totaling 25 inputs, while the inputs for the second ANN was R, G , B, Color Value, R Index , G Index, B Index, H, S, and I, totaling 10 inputs. After the training process, other new sets of samples were used to validate the ANN.

Material and Methods

Shape and color components of bean samples were extracted by the Visual Basic programs. Their unique characteristics were expected to occurs in order to make the classification easy. But several of the characteristic are not unique among the type of cocoa bean, so that the ANN is expected to be able to distinguish the differences.

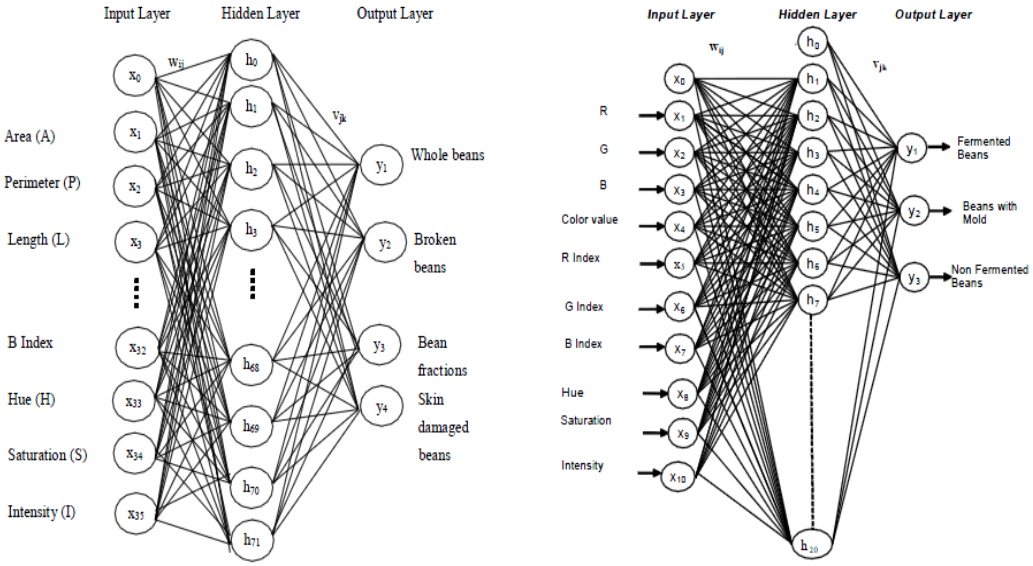


Figure 5. The two ANN structures

Table I. R, G, B Color Components Characteristic of Cacao Beans

eans Type	R		G		B		CV	
	Avera ge	Range	Avera ge	Range	Aver age	Range	Average	Range
ermented eans	153.78	95-195	97.21	69-126	55.83	33-79	3683668	2180728-5206952
loldy beans	166.00	121-203	131.87	91-172	95.02	56-133	6260849	3367330-8760519
Non ermented eans	183.25	158-208	119.96	98-143	73.24	51-92	4830152	3367582-6066121

Table II. H, S, I Color Components Characteristics of Cacao Beans

Bean Type	*Hue*	*Saturation*	*Intensity*
Fermented beans	2.57	0.46	102.72
Moldy beans	0.83	0.28	131.38
Non fermented beans	0.56	0.42	125.95

The progress of ANN training processes are shown in Figure 6. The ANNs achieved good accuracy after hundreds of iterations. The training of the first ANN is seemly having an over fitted condition as can be shown from the validation result, where the validation result has a considerable different accuracy compared with the validation result.

Table III. H, S, I, Index Color Components Characteristics of Cacao Beans

Bean Type	I_{red}	I_{green}	I_{blue}
Fermented beans	0.50	0.32	0.18
Moldy beans	0.42	0.33	0.24
Non fermented beans	0.49	0.32	0.19

Better accuracy is shown by the second ANN as it is can be predicted from the beginning that the differences in the characteristics are more clear. The difference is clear in their color. Table VI and Table VII shows that there is no significant change in the accuracy from training process and the validation process. The same fact was not shown by the first ANN where the change of 20% occurs from training process to validation process. The number of training samples has been big enough so that there is a very small probability of being incomplete samples. The reason is that their characteristics in most cases are naturally similar. Different characteristic is shown only by bean fractions which have a relatively small size.

Table IV. R, G, B Color Components Characteristics f Cacao Beans

Bean Type	Numer of samples	Classification Result						Ratio of perfect claasification	Accuracy (%)
		Whole beans	Broken beans	Bean Fractions	Skin damaged beans	Unknown	Double class		
Whole beans	522	520	0	0	1	1	0	520/522	99.62
Broken beans	203	3	197	0	0	3	0	197/203	97.04
Bean fractions	387	0	0	387	0	0	0	387/387	100.00
Skin damaged beans	133	2	0	0	121	10	0	121/133	90.98
Total	1245							1225/1245	98.39

Table V. R, G, B Color Components Characteristics of Cacao Beans

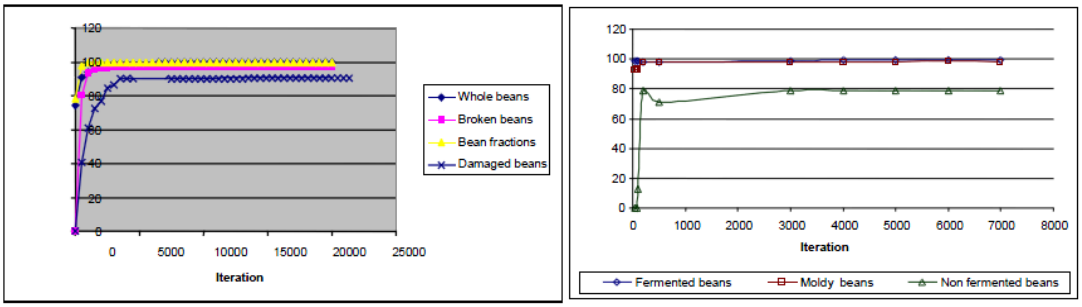
Bean Type	Numer of samples	Classification Result						Ratio of perfect claasification	Accuracy (%)
		Whole beans	Broken beans	Bean Fractions	Skin damaged beans	Unknown	Double class		
Whole beans	224	189	2	0	12	16	5	189/224	84.38
Broken beans	58	5	30	4	2	8	9	30/58	51.72
Bean fractions	117	0	0	115	0	0	2	115/117	98.29
Skin damaged beans	30	18	2	0	6	3	1	6/30	20.00
Total	429							340/429	79.25

Table VI. R, G, B Color Components Characteristics of Cacao Beans

Beans Type	Number of samples	Classification Results				Ratio of correct classification	Accuracy (%)
		Fermented beans	Moldy beans	Non fermented beans	Unclassified		
Fermented beans	313	311	-	2	-	311/313	99.36
Moldy beans	177	3	174	-	-	174/177	98.30
Non fermented beans	24	5	-	19	-	19/24	79.17
Total						504/514	98.05

Table VII. R, G, B Color Components Characteristics of Cacao Beans

Beans Type	Number of samples	Classification Results				Ratio of correct classification	Accuracy (%)
		Fermented beans	Moldy beans	Non fermented beans	Unclassified		
Fermented beans	274	262	2	7	3	262/274	95.62
Moldy beans	197	25	161	-	11	161/197	81.72
Non fermented beans	35	7	-	25	3	25/35	71.43
Total						448/506	88.54



Chapter 6. Progressess on ANN Trainings

Conclusions and Suggestions

The tool for cocoa bean classification have been developed consisting of image a processing module and a classification module. The image processing module extracts the bean image in order to gain shape and color characteristics such as area, perimeter, length, segment widths, roundness, R, G, B, color value, hue, saturation, and intensity. Classification module uses two neural network structures to classify the cocoa beans into it breakage sizes and fermentation status. Breakage size classification achieved its 79.25% accuracy, consisting of 84.38% accuracy for whole beans, 51.72% for broken beans, 98.29% for bean fraction, and 20% for damaged bean. Fermentation status classification has its accuracy of 88.54 %, consisting of 95.62 % for fermented beans, 81.72 % for moldy beans, and 71.43 % for non fermented beans.

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