An Efficient Method for Quality Analysis of Rice Using Machine Vision System

Rahul Birla and Ajay Pal Singh Chauhan
Electronics and Communication Engineering Department, Sant Longowal Institute of Engineering and Technology
Longowal-148106, Punjab, India
Email: rhlbirla58@gmail.com; ajaypal@sliet.ac.in

***Abstract*—Agricultural industry is the oldest industry in the world. There are numerous challenges faced by this industry in proper quality analysis. Quality assessment of grains is a very big challenge for a long time. This paper presents a solution for quality assessment and grading of Indian basmati Oryza sativa L variety rice using machine vision and image processing. Basic problem of rice industry for quality assessment is addressed which is traditionally done manually by human inspectors. Machine vision provides an alternative with automated, non-destructive, cost-effective, and fast approach method. Quality analysis is done using computer vision, image analysis and processing as compared to human vision inspection. This paper presents an efficient method for calculating the size of Oryza sativa L rice using machine vision along with detection of chalky and broken rice with improved accuracy compared with human inspectors.**

***Index Terms*—machine vision, quality, image processing, image analysis, Oryza sativa L**

I. Introduction

Agricultural industry is probably the most widespread and oldest industry in the world. Agricultural industry is being replaced with automated machinery instead of human efforts with lot of improvements [1]. In India it is necessary to make advancement in agricultural industry to overcome the need of ever-increasing population. High quality and safety standards can be achieved in an accurate, fast and cost effective way with the help of automation employing machine vision [2], [3], [4], [5]. Quality control is of major importance in the food industry. Traditionally quality of food product is defined from its visual appearance by human inspector which is time consuming, maybe with varying results. Human results are inconsistent and less efficient with respect to automated system so the objective is to replace the traditional methods with automated systems. Engineers have successfully used computers with machine vision by digital cameras and machines [6], [7], [8], [9].

Oryza Sativa (Rice) is a vital worldwide agriculture product. More than half of the world's population depends on rice as their food source especially in India. Oryza Sativa L (Rice) is the major source of calories and protein. Rice (Oryza sativa L) is mainly grown in countries such as India, China, Indonesia, Bangladesh and Thailand which are considered as the major producers. India is the world's 2nd largest producer and consumer country of rice for a very long time. Quality evaluation of Oryza sativa rice based on its size using machine vision is reported [10] [11]. Work on inspection of chalkiness of rice is also reported [12], [13].

Based on the literature survey, in the present work a method is proposed for quality analysis of Oryza Sativa L variety rice by the combination of size, broken and chalkiness Section 2 discusses the problem definition for improving quality Basmati Rice (Oryza sativa L). Section 3 discusses about the materials and methods proposed for calculating parameters for the quality of rice. Section 4 discusses the results obtained on basis of analysis of rice based on image processing and machine vision techniques. Section 5 provides the conclusion and future work of the process.

Manuscript received June 11, 2015; revised August 5, 2015.

II. Problem Defintion

In agricultural industry quality assessment of product is of main concern. Nowadays, the quality of grain seed has been determined manually through a visual inspection by experienced personals. So it requires high degree of accuracy, high level of quality as well as correctness for a nondestructive quality evaluation method to satisfy customer need. Machine vision proved to be an effective tool that could be used to replace human inspectors for reliable and consistent judgment in estimating and comparing quality of seeds.

Basmati rice (Oryza sativa L) seed can be normal, long or small in size and defected seed can be chalky or broken as shown in Fig. 1. The blue highlighted boundaries are normal, red colored ones are long and green highlighted boundaries are small seed. Brown highlighted boundaries are chalky seed and yellow colored ones are broken seed. Normal seeds are most important while quantifying quality. These seeds are selected after the processing of seeds using image analysis. If not properly selected then degradation of quality of rice may occur. This paper proposes a new method for counting the number of Basmati rice (Oryza sativa L) seeds in terms of size as well as defected seed using machine vision processes with non-destructive technique to quantify the quality of Basmati rice(Oryza sativa L) seeds.

doi: 10.12720/jait.6.3.140-145

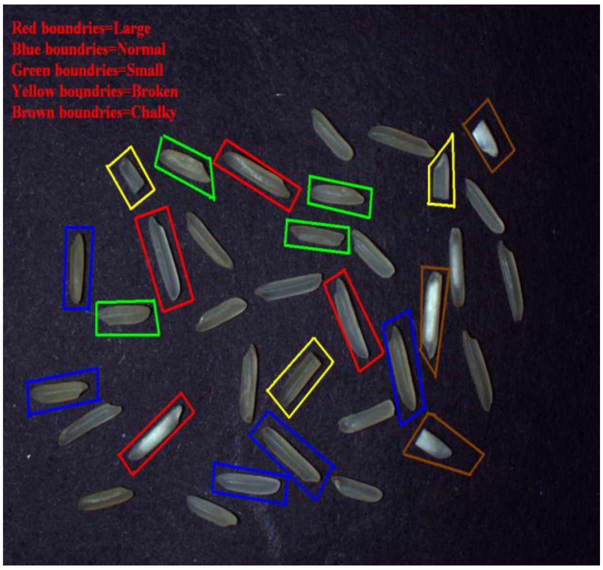


Figure 1. Rice seed with and without foreign elements and defected seed.

III. Materials and Method

In this section, the proposed algorithm is discussed. Here, different varietal samples of Basmati rice are used. The number of Basmati rice (Oryza sativa L) seeds with long seeds, normal seeds as well as small seeds has counted by using perimeter of rice seed. Perfect thresholding and object detection has been used for calculating the number of chalky rice. Object classification has been used for calculating the number of broken rice.

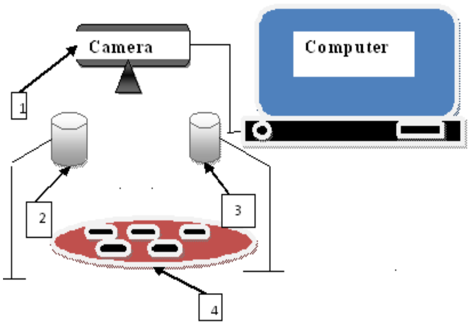


Figure 2. Proposed machine vision system for analysis and processing

A. System Description and Operating Procedure

Block diagram of the proposed system is shown in Fig. 2.In the proposed system there is a 2-D camera, which is mounted on the top at point 1 as shown in Fig. 2. The camera is having 12-mega pixels quality with 8 X optical zoom. After capturing images of rice seed by camera, it is stored for further processing. Two illumination sources at point 2 and 3 in Fig. 2 are used to overcome the problem of luminance and for good quality of image. Red paper can also be used for uniform distribution of light on the tray. The rice seeds are placed on the tray for capturing an image at point 4 in Fig. 2.

The simplicity of operation of system can be asserted from the operating procedure detailed in Table I.

TABLE I. Operating Procedure for Proposed System

Sr. No.	STEPS
1	Spread the seeds uniformly on the Tray to avoid Overlapping of seeds.
2	Capture image of seeds using camera
3	Process and analyze digital image in computer
4	Display number of normal rice seeds, long seeds, small seeds, chalky seeds and broken seeds.
5	Repeat above steps for 10 to 15 samples.

B. Proposed Algorithm to Detect Rice Seeds with Long Seeds, Small Seeds and Defected Seeds

TABLE II. Steps

Sr. No.	STEPS
1	Image acquisition
2	Pre-processing
3	Object detection
4	Particle analysis
5	Particle classification
6	Calculator setup
7	Custom overlay

Pre-processing: First, RGB color image are converted in to grayscale image by extracting green color plane. Then adjust the manual thresholding range so that chalkiness in all rice grain must be detected. Then again whole gray level image is converted into binary image so as to convert all rice seeds into the binary form by using manual thresholding. Chalkiness in rice seeds as well as whole binary image and gray level image after thresholding are shown in Fig. 3.

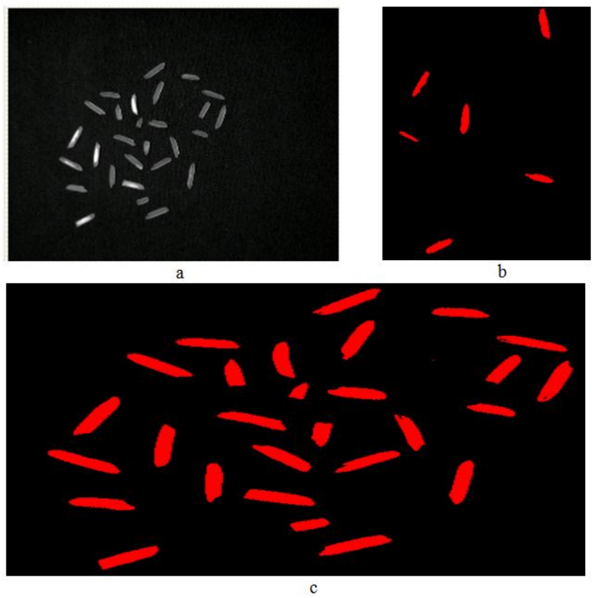
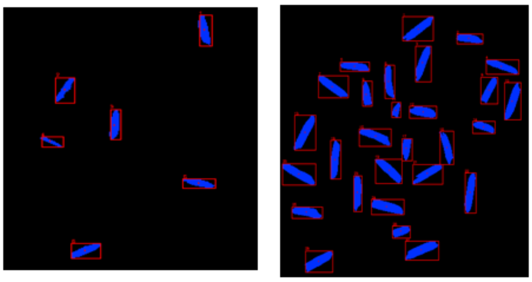


Figure 3. Pre-processing image of rice seeds a) gray scale b) chalky binary and c) binary image of all rice seeds.

Object detection: In this paper object detection is used for two purposes one for detection of chalky rice seeds and another for detection of all rice seeds.

First whole image is being selected as a region of interest. After specifying a region of interest, the step automatically tries to locate objects in the region. Pixels with intensity values in the specified threshold range appear blue in the image. Label mark the bounding rectangles of each individual object that the step located. This step gives the result in terms of number of chalky rice and number of all rice seeds. Fig. 4 (a) shows the binary image of chalky portion in rice seeds and Fig. 4 (b) shows the binary image of all rice seeds after object detection.



(a) (b)

Figure 4. Binary image of chalky portion of rice and all rice seeds after object detection

TABLE III. COMPUTED THRESHOLD VALUES IN PIXELS

Parameter	Small	Normal	Large
Perimeter (Pixels)	0-180	181-230	231-400

Particle analysis: Particle analysis consists of a series of processing operations and analysis functions that produce information about particles in an image. Using particle analysis, detection and analysis of any 2D shape in an image can be done. Particle analysis is used when need is there to find particles whose spatial characteristics satisfy certain criteria. In many applications where computation is time-consuming, particle filtering can be used to eliminate particles that are of no interest based on their spatial characteristics, and to keep only the relevant particles for further analysis. In this paper particle analysis has been used to find out perimeter of all rice seeds and set the perimeter range to eliminate rice seeds that are of no interest. So particle analysis has much more importance before particle classification. After computing threshold value of perimeter of rice seed, number of normal rice seed as well as small rice seeds and large rice seeds are found. Computed threshold value in pixels of rice seeds is shown in Table III.

Particle classification: Classification identifies an unknown sample by comparing a set of its significant features to a set of features are compared that conceptually represent classes of known samples [14]. A particle classifier uses feature vectors to identify samples based on their shape. A color classifier uses color features to identify samples based on their color. Classification involves two phases: training and classifying. Training is a phase during which one teaches the machine vision software the types of samples one want to classify during the classifying phase. Training can be done on any number of samples to create a set of classes, which one later compare to unknown samples during the classifying phase. The classes are stored in a classifier file. Training might be a one-time process, or it might be an incremental process one repeat to add new samples to existing classes or to create several classes, thus broadening the scope of samples one want to classify. Classifying is a phase during which one's custom machine vision application classifies an unknown sample in an inspection image into one of the classes one trained. The classifying phase classifies a sample according to how similar the sample features are to the same features of the trained samples. The need to classify is common in many machine vision applications. In this paper particle classification has been used three times to classify broken rice seeds, small rice seeds, normal rice seeds and large rice seeds. Fig. 5 shows particle classification step.

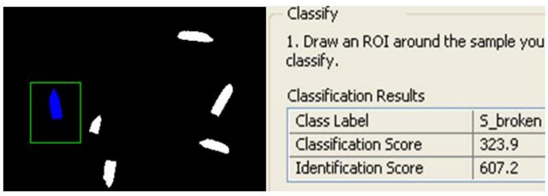


Figure 5. Particle classification image

Calculator setup: calculator step has been used to combine measurements from previous steps to compute new results. The new results can be the outcome of a numeric computation, comparison or logical operation, or a string manipulation. The percentage of chalky rice seeds, broken rice seeds, small rice seeds, normal rice seeds and large rice seeds are determined by using following formula:

Percentage of required objects = (number of required objects / number of total objects) x 100

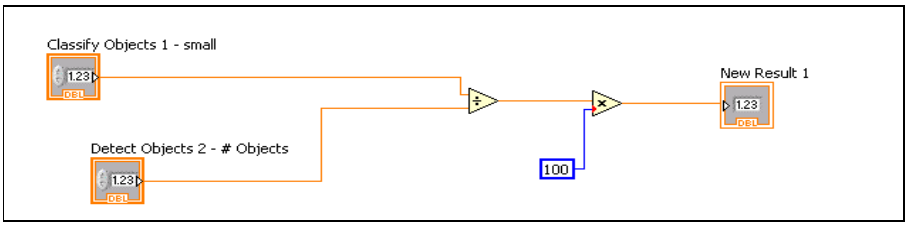


Figure 6. Calculator setup for chalky rice seeds

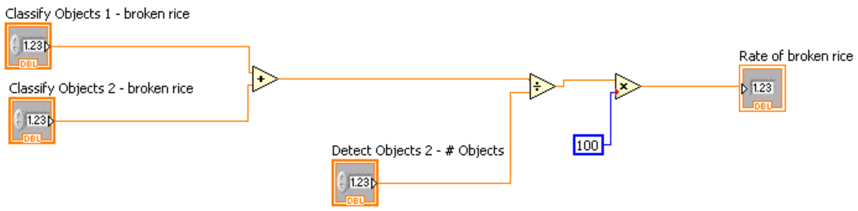


Figure 7. Calculator setup for broken rice seeds

Calculator setup for chalky rice seeds is shown in Fig. 6. Since broken can come into the category of small and normal rice seeds. So another calculator setup is used to calculate percentage of broken rice seeds as shown in Fig. 7.

Custom overlay: Custom overlay step is used to display the current image and overlay shapes, text, and additional images on an image without modifying the image data. Fig. 8 shown custom overlay image of small rice seeds.

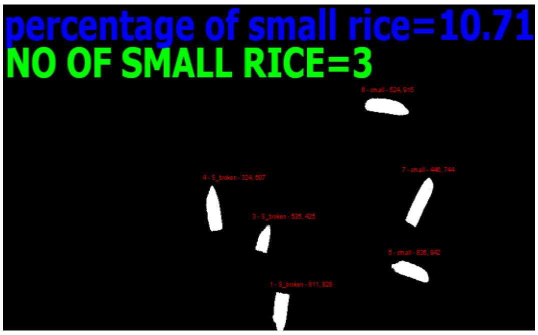


Figure 8. Custom overlay image of rice seeds

IV. Results Analysis

TABLE IV. Result Analysis of Different Seeds Present in One Sample Using Image Analysis

Sr. No.	Perimeter (Pixels)	Sr. No.	Perimeter (Pixels)
1	198	14	209
2	198	15	116
3	176	16	203
4	199	17	223
5	198	18	226
6	236	19	187
7	227	20	225
8	114	21	237
9	177	22	211
10	121	23	148
11	206	24	216
12	190	25	196
13	209	26	218

Classification of rice seeds is done based on assessment of perimeter. Table IV shows intended perimeter value based on particle analysis for all seeds present in one sample. Table V shows distinction between normal, small, large as well as broken seed based on particle analysis, particle classification and object detection. Table VI shows percentage wise calculated values based on total number of seeds present in a sample using machine based image analysis. Table VII shows distinction between normal, small, large as well as broken seeds done by human inspector. Similarly Table VIII shows percentage wise calculated values based on total number of seeds present in a sample. Table IX shows

TABLE V. Result Analysis of Different Samples Based on Image Analysis

Sample no	Small seed	Normal seed	Large seed	Broken seed	Total seeds
1	3	15	3	7	28
2	4	20	2	5	31
3	2	16	2	6	26
4	2	19	3	8	32
5	3	19	2	6	30
6	2	18	4	7	31
7	2	18	4	3	27
8	3	19	3	4	29
9	4	19	2	4	29
10	2	17	4	6	29
11	2	18	5	5	30
12	2	18	4	6	30
13	2	20	2	8	32
14	4	17	3	6	30
15	2	18	4	6	30

TABLE VI. Result Analysis of Different Samples Based on Percentage Value

Sample no	Total seeds	Normal seed%	Small seed%	Large seed%	Broken seed%
1	28	53.57	10.71	10.71	25.00
2	29	64.52	12.90	6.45	16.13
3	26	61.54	7.69	7.69	23.08
4	32	59.37	6.25	9.37	25.00
5	30	63.33	10.00	6.67	20.00
6	31	58.06	6.45	12.90	22.58
7	27	66.67	7.41	14.81	11.11
8	29	65.52	10.34	10.34	13.79
9	29	65.52	13.79	6.90	13.79
10	29	58.62	6.90	13.79	20.69
11	30	60.00	6.67	16.67	16.67
12	30	60.00	6.67	13.33	20.00
13	32	62.50	6.25	6.25	25.00
14	30	56.67	13.33	10.00	20.00
15	30	60.00	6.67	13.33	20.00
Average		61.05	8.80	10.61	19.52

Chalkiness detection using Image analysis by machine vision method as well as if done by human inspector, it can be clearly seen from the results presented in Tables that the results are more accurate if analysis is done using machine vision based systems in comparison to human inspector. As shown in Table X for same number of seeds in each sample there is a significant improvement of 10.99 % for detection of normal seeds and 2.27 % for chalky seeds.

TABLE VII. RESULT ANALYSIS OF DIFFERENT SAMPLES BASED ON HUMAN INSPECTOR

Sample no	Small seed	Normal seed	Large seed	Broken seed	Total seeds
1	4	14	4	6	28
2	5	17	3	6	31
3	3	14	3	6	26
4	4	17	4	7	32
5	4	15	4	7	30
6	3	15	5	8	31
7	4	14	5	4	27
8	4	15	4	4	29
9	6	14	4	5	29
10	5	15	5	4	29
11	4	14	6	6	30
12	3	15	5	7	30
13	3	16	4	9	32
14	5	14	4	7	30
15	3	15	5	7	30

TABLE VIII. RESULT ANALYSIS OF DIFFERENT SAMPLES BASED ON PERCENTAGE VALUE OF HUMAN INSPECTOR

Sample no	Total seed	Normal seed%	Small seed%	Large seed%	Broken seed%
1	28	50.00	14.28	14.28	21.42
2	29	54.83	16.12	9.67	19.35
3	26	53.84	11.53	11.53	23.07
4	32	53.12	12.50	12.50	21.87
5	30	50.00	13.33	13.33	23.33
6	31	48.38	9.67	16.12	25.80
7	27	51.85	14.81	18.51	14.81
8	29	51.72	13.79	17.24	17.24
9	29	48.27	20.68	13.79	17.24
10	29	51.72	17.24	17.24	13.79
11	30	46.66	13.33	20.00	20.00
12	30	50.00	10.00	16.66	23.33
13	32	50.00	9.37	12.50	28.12
14	30	46.66	16.66	13.33	23.33
15	30	50.00	10.00	16.66	23.33
Average		50.46	12.21	16.48	21.06

TABLE IX. CHALKINESS CALCULATION

Sample No.	Total seed	By Image analysis		By Manually	
		Chalky seed	Chalky seed %	Chalky seed	Chalky seed %
1	28	6	21.43	5	17.85
2	31	7	22.58	4	12.90
3	26	5	19.23	4	15.38
4	32	7	21.87	6	18.75
5	30	6	20.00	5	16.66
6	31	5	16.13	6	19.35
7	27	4	14.18	3	11.11
8	29	5	17.24	5	13.79
9	29	4	13.79	3	10.34
10	29	6	20.69	5	17.24
11	30	5	16.67	4	13.33
12	30	4	13.33	5	16.66
13	32	7	21.87	6	18.75
14	30	6	20.00	4	13.33
15	30	3	10.00	5	16.66
Average			18.19		15.47

TABLE X. ERROR CALCULATION

Average normal seed%		Error %	Average chalky seed%		Error %
By image analysis	By manually	10.59	By Image analysis	By manually	2.27
61.05	50.46		18.19	15.47	

V. CONCLUSION AND FUTURE WORK

This paper proposes a new non destructive method for quality analysis of Basmati rice seeds via image analysis. Since error in detecting average percentage of normal seed and average percentage of chalky seed are 10.59 % and 2.27 % respectively. So it can be emphasized that the proposed system is 10.59 % and 2.27 % more accurate than human inspector for normal seed and chalkiness estimation respectively. So the proposed system is giving promising results in comparison to human inspector. For further expansion of quality analysis, more parameters can be added to make accuracy even higher. Soft computing classification and neural network approach can be used for unknown samples and to further expand the work.

REFERENCES

[1] M. Z. Abdullah, A. S. Fathinul-Syahir, and B. M. N. Mohd-Azemi, “Automated inspection system for color and shape grading of star fruit (Averrhoa carambola L.) using machine vision Sensor,” *Transactions of the Institute of Measurement and Control*, vol. 27, no. 2, pp. 65-87, 2005.

[2] M. Kurita and N. Kondo, “Agricultural product grading method by image processing (part 1) - effectiveness of direct lighting method,” *J. SHITA*, vol. 18, no. 1, pp. 9-17, 2006.

[3] R. Kambo and A. Yerpude, “Classification of basmati rice grain variety using image processing and principal component analysis,” *International Journal of Computer Trends and Technology*, vol. 11, no. 2, pp. 80-85, 2014.

[4] R. Kiruthika1, S. Muruganand, and A. Periasamy. “Matching of different rice grains using digital image processing,” *International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering*, vol. 2, no. 7, pp. 2937-2941, 2013.

[5] L. Z. Xu and Y. M. Li, “Multi-scale edge detection of rice internal damage based on computer vision,” *International Conference on Automation and Logistics Qingdao*, 2008.

[6] P. Patil, “Reliable quality analysis of indian basmati rice using image processing,” *International Journal of Engineering & Technology*, 2014.

[7] Q. Yao, J. H. Chen, Z. X. Guan, C. X. Sun, and Zhiwei Zhu, “Inspection of rice appearance quality using machine vision,” *Global Congress on Intelligent Systems*, 2009.

[8] A. G. OuYang, R. J. Gao, Y. D. Liu, X. D. Sun, Y. Y. Pan, and X. L. Dong, “An automatic method for identifying different variety of rice seeds using machine vision technology,” in *Proc. Sixth International Conference on Natural Computation*, 2010.

[9] Y. Akiyama, Y. Takahara, and K. Yamamoto, “The application of image analysis to valuation on whitecore in grain of rice for sake brewery (In Japanese with English abstract),” *Breeding Science*, vol. 46, no. 4, pp. 367-371, 1996.

[10] C. V. Maheshwari, K. R. Jain, and C. K. Modi, “Non-destructive quality analysis of Indian Basmati Oryza Sativa SSP Indica (Rice) using image processing,” in *Proc. International Conference on Communication Systems and Network Technologies*, 2012, pp. 189-193.

[11] N. K. Jain, S. O. Khanna, and K. R. Jain, “Development of a classification system for quality evaluation of oryza sativa L.(Rice) using computer vision,” in *Proc. Fourth International Conference on Communication Systems and Network Technologies*, 2014, pp. 1088-1092.

[12] L. T. Xiao, D. H. Li, W. H. Ln, B. Hong, and Y. H. Hong, "An objective method to measure chalkiness of rice grain (In Chinese with English abstract)," *Chinese J. Rice Sci.*,vol. 15, no. 3, pp. 206-208, 2001.

[13] X. Y. Huang, S. Y. Wu, R. M. Fang, and Y. K. Luo, "Inspection of chalk degree of rice using genetic neural network (In Chinese with English abstract)," *Trans. CSAE*, vol. 19, no. 3, pp. 137-139, 2003.

[14] National instrument corporation, "NI Vision Concepts Manual," *Worldwide Technical Support and Product Information*, 2005.

Rahul Birla was born in Roorkee in 1988. He has done his B.Tech in Electronics and Telecommunication Engineering from College of Engineering Roorkee, Roorkee, Uttarakhand, India. Now he is persuing his M.Tech in Electronics and Communication Engineering from Sant Longowal Institute of Engineering and Technology, Longowal, Punjab, India since 20.13. His area of interest includes image processing.

Dr. Ajay Pal Singh Chauhan is working as Asssociate Professor in Electronics and Communication Engineering Department at Sant Longowal Institute of Engineering and Technology (Deemed University) Longowal, Sangrur (Punjab) INDIA. His area of interest is Image Processing. He is having 19 years of teaching experience with number of papers published in National/International conferences/journals.