Implementation of Rice grain Quality Testing on FPGA using Image Proccessing

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Abstract-The quality of rice grains is one of the most significant aspects in fulfilling the consumer requirements.The classification of food grains is done based on their external features.Generally visual inspection is done to evaluate the quality parameters of rice grains which is a difficult task in terms of consumption of time,rapidity and finally the accuracy. Hence to overcome these constraints an automated system as to be developed to analize the quality of rice grains.The present work is focused on devoloping a robust algorithm in identifying the samples of rice grains based on their quality parameters like area, perimeter, length, width, aspect ratio, major axis, minor axis, etc.The classification of rice grains was proposed with an image processing algorithm after range filtering to extract the quality features of rice grains with more accuracy. These features are given to the SVM classifier for training purpose which is then used in identifying the samples of rice grains for further classification.

Index Terms –Rice grain samples,Range Filtering,Thresholding,Image processing,Quality parameters,SVM Classifier,Classification

1 INTRODUCTION

Agriculture is known as backbone of India. Rice is one of the biggest harvesting crop in agricultural feild. Rice is grown around 100 countries as it is staple food of half of the world's population.According to the survey,it is known that there exists more than 40,000 varieties of rice worldwide.Among these more than 100 varieties are cultivated.An illustrative comparision of bulk varieties of rice grains is done based on their physical quality,protein quality,vitamin and mineral quality etc.In previous days , the grain quality and grain testing is done using biological methods and chemical analysis methods which are very expensive and time consuming.Even the chemical analysis methods would destruct the grain samples.Further the evaluation process done by human inspection depends on his/her physical conditions like eye sight, mental conditions and even working conditions like lighting, climate, etc. All these factors in examining the rice grains would finally affect farmers and consumers.

Hence to overcome the above constraints an automation procedure should be implemented to analyze, and classify the rice grains based on their physical quality.Image analysis is one of such automated method which is less time consuming, accurate and more efficient.The physical quality of rice grains is analyzed based on their length, width, area, aspect ratio, colour, texture etc.

Different algorithms can be used to classify samples of rice grains based on its quality. In the proposed work, quality parameters are measured using image processing techniques.Finally,SVM(Support Vector Machine) classifier is used to classify the rice grain samples.

1.1 Advantages

i. The intervension of human beings for visual inspection can be reduced.
ii. No skilled expert is required to judge the quality of rice grains.
iii. Time spent on testing the quality of rice grains can be saved.
iv. The accuracy in attaining the quality parameters will be high compared to the visual inspection.

2 MATERIALS USED

In this work, rice grain samples of five varieties namely,Bapatla, Basmathi, Kholam, Rawrice, Sonamasuri with different sample sizes were taken.

A set of 6 sample images of each variety with different rice grain sample sizes were acquired.Each image is captured with a pixel size of approximately 454 x 465 pixel size. The seeds which are rice grains are captured with a condition that the grains should not touch each other.)

Matlab-2014a tool was used for implementing image processing algorithm.Initially the rice grain sample images are filtered using range filter to extract the texture features of rice grains.Range filter enhances the visibility of the edges of the rice grains.Then the rice grain samples are segmented using thresholding method. The verilog implementation is done using Modelsim-Altera tool and synthesis was done using Xilinx ISE 14.1 by selecting a target device Spartan-3E FPGA.

3 METHEDOLOGY

In this work the images of Bapatla, Basmati, Kholam, Raw rice and Sonamasuri rice grain samples were taken for quality analysis. These rice grain samples were further processed by converting in to binary image using thresholding method. Further the quality features like Area, Perimeter, Equidiameter, BoundingBox, Length, Width, Rectangular Aspect ratio, MajorAxis Length, MinorAxis Length, Aspect ratio, Solidity, Eccentricity are extracted on a set of samples of rice grain images with different sample sizes. Finally SVM(Support Vector Machine) classifier is used to classify the rice grains based on their quality parameters.The block diagram of the flow of the project is shown in Fig 1

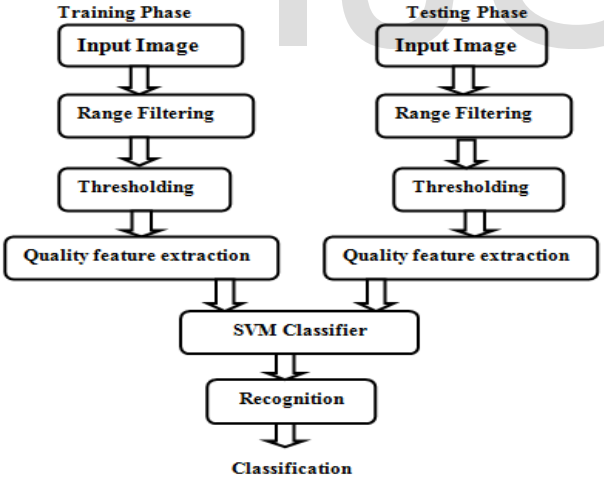


Fig 1 Block diagram representing the flow of the project

3.1 Image Acqisition

The images of Bapatla, Basmati, Kholam, Raw rice, Sonamasuri rice grain samples were acquired using camera Lumia 550 (Microsoft) at a distance of 800 mm(approx.).A number of seeds which are rice grains were taken randomly,subjecting to a condition that the rice grains should not touch each other.Fig-2 shows the block diagram of image acquisition.

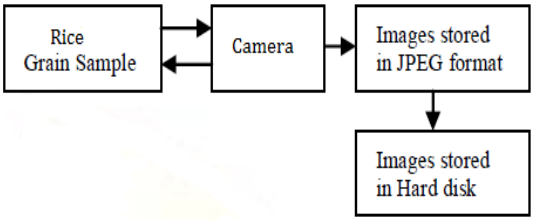


Fig 2 Block diagram of Image acquisition

3.2 Image Preprocessing

In order to extract rice grain features accurately,the rice grain samples are to be preprocessed. First the image is resized in to a size of 512 x 512 pixels.Further to enhance the texture features of rice grains range filter is used. The rice grains surfaces exhibit more texture..Then the images are converted to gray level images. These gray-scale images are converted to binary using thresholding segmentation. Thresholding subdivides the image in to different pixels by isolating the rice grains from its background.

3.3 Range filter

The range filter enhances the texture features of rice grain samples.Compared to other texture filtering functions range filter as an advantage of enhancing the visibity of the texture features of rice grain samples by selecting the high range of values in the areas of rough texture of a rice grain sample.By default range filter function uses a 3 x 3 neighbourhood to calculate the range of texture values of rice grain samples.

The range filtering is done by subtracting the minimum pixel value with the maximum pixel value of an image in a selected 3x3 neighbourhood.Fig 3 shows the functionality of range filter.

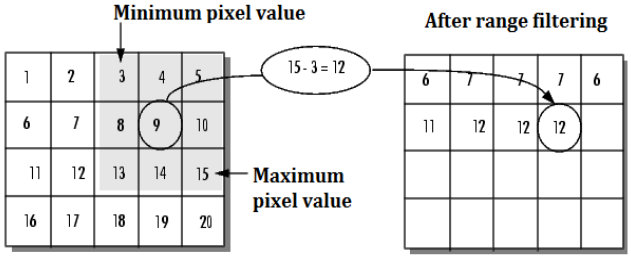


Fig 3 Functionality of range filter

3.4 Calculation of Quality Parameters

The Physical Features of rice grain samples namely Area, Perimeter, Equidiameter, BoundingBox, Length, Width, Rectangular Aspect ratio, MajorAxis Length, MinorAxis Length, Aspect ratio, Solidity, Eccentricity are calculated using region props function. These parameters are calculated based on pixels covered by the grains in

each image. The Pixels covered by rice grains in every image depends on distance between camera and object.

3.4.1 Seeds

The Seeds are the rice grain samples taken for the analysis of quality features.

3.4.2 Area

The area of samples of rice grains was the total sum of the pixels covered by in and out boundaries of a seed.

3.4.3 Equidiameter

The Equidiameter of rice grains was calculated using below formula.

Eqd=sqrt(4*Area/pi).

3.4.4 Perimeter

The Perimeter of rice grains is the distance between each adjoining pair of pixels present along the border of the grains.

3.4.5 BoundingBox

The smallest rectangle containing the specified vectored region enclosing the rice grains are used to calculate length and width of rice grains .

3.4.6 Length

The maximum length of the rectangle bounding the the rice grains was used to calculate the length of the grains.

3.4.7 Width

The minimum length of the rectangle bounding the rice grains was used to calculate the width of the grains.

3.4.8 Rectangular aspect ratio

The rectangular aspect ratio of rice grains was calculated from the ratio of length and width of the grains.

3.4.9 Major axis length

The major axis were computed from the pixel distance between every combination of border pixels of rice grain boundary.

3.4.10 Minor axis length

It was the distance between the end points of the longest line, drawn through the seed which is perpendicular to the major axis.

3.4.11 Aspect ratio

The aspect ratio of rice grains was calculated from the ratio of Major axis length to the Minor axis length.

3.4.12 Convex Area

The convex area was calculated from the number of pixels covered in the convex region of rice grains

3.4.13 Solidity

It was calculated from the proportion of the pixels in the smallest convex polygon covered by rice grains.

Solidity of rice grains was computed as

S= Area/Convex Area.

3.4.14 Eccentricity

The eccentricity was calculated from the ratio of the distance between the foci and majoraxis length of the rice grains. The value of eccentricity lies between 0 and 1.

4 CLASSIFICATION

The classification of grains is done based on their 13 quality parameters. Support Vector Machine (SVM) Classifier was used to classify rice grain samples.

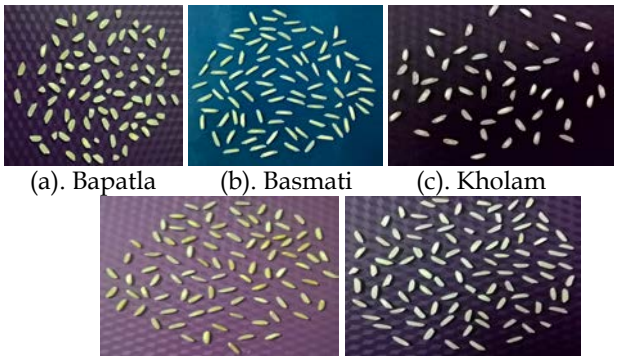
4.1 Support Vector Machine

Support Vector Machine algorithm was invented by Vladimir Vapnik. It is one of the widely used learning classifier for data analyzing and detection. Basically, SVM idea is to generate an hyper plane among the data sets to specify a particular group it belongs to. It trains the given data set to understand its features,structure and then maps to the corresponding class accurately. It is expressed as a weighted sequence of kernel functions on a set of data given for training. Then the other set of data is given for testing and further classification. SVM's has favorable properties compared to other classifiers like general faster training, easy configuration and satisfying theoretical properties.

In the present work, the SVM classifier was trained with five different types of rice grains namely Bapatla, Basmati, Kholam, Rawrice, Sonamasuri with a set of samples. Further testing was done on the other set of samples those are different from trained data. From this testing data quality features were extracted and compared with that of trained data set. The samples those are matched with the quality parameters stored in database were recognized and classified in to a particular type of rice grain.

5 RESULTS

Matlab-R2013a tool is used for implementation. Original rice grain sample images of five varieties of rice grains namely,Bapatla, Basmati, Kholam, Rawrice, Sonamasuri taken for analysis are shown from Fig 4(a) – 4(e).

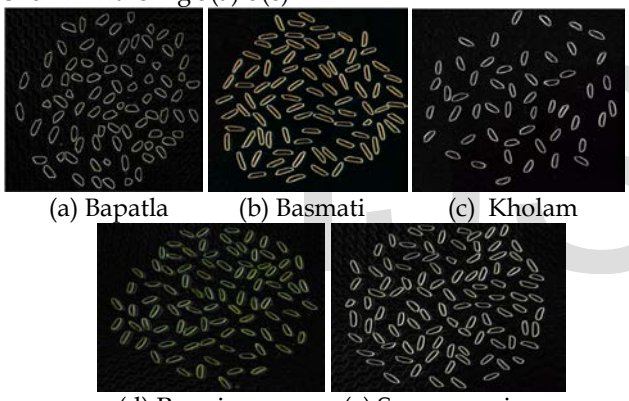


(a). Bapatla (b). Basmati (c). Kholam

(d). Raw Rice (e). Sonamasuri

Fig 4(a)-4(e). Samples of five rice grain varieties

Initially to enhance the texture areas of rice grain samples the images are filtered using range filter.Range filtering enhances the visibility of edges of rice samples.The rice grain samples after range filtering are shown in the Fig 5(a)-5(e)

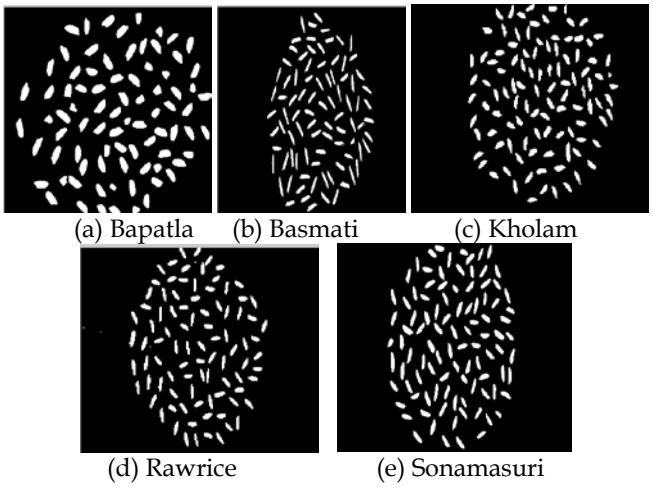


(a) Bapatla (b) Basmati (c) Kholam

(d) Rawrice (e) Sonamasuri

Fig 5(a)-5(e). Rice grain samples after filtering.

After filtering the rice grain samples were segmented using thresholding method.Fig 6(a)-6(e) shows the samples after segmentation.



(a) Bapatla (b) Basmati (c) Kholam

(d) Rawrice (e) Sonamasuri

Figure-6(a)-6(e) Rice samples after segmentation.

After applying image processing techniques, 13 quality parameters like area, equidiameter, bounding box, perimeter, length, width, rectangular aspect ratio, major axis, minor axis, aspect ratio, convex area, solidity and eccentricity of five rice grain samples are evaluated.The mean values of 13 quality features extracted from the test images of five rice grain samples are given to the SVM classifier for further classification

The mean values of rice grain samples are tabulated in Table 1.

Table 1 Mean Values of Quality features of five rice grain samples.

Mean of Quality parameters	**Rice Grain Varieties**				
	Bapatla	**Basmati**	**Kholam**	**RawRice**	**Sonamasuri**
No of Rice grains	47	43	55	78	59
Area	453.45	197.96	209.10	52.18	219.45
Equi diameter	23.85	15.70	15.88	5.64	16.66
Perimeter	87.27	73.56	70.60	22.07	71.20
Length	24.54	18.81	13.18	5.50	15.01
Width	30.00	26.93	28.78	8.63	28.89
RASR	0.89	0.94	0.54	0.88	0.62
MajorAxis	34.94	33.90	30.689	9.95	32.18
MinorAxis	16.90	7.90	9.01	3.83	9.16
ASR	2.08	4.63	3.58	2.02	3.73
ConvexArea	470.86	216.37	228.30	59.34	233.86
Solidity	0.96	0.91	0.918	0.92	0.93
Eccentricity	0.84	0.96	0.918	0.57	0.941

Table 2 Statistics of iterations

6 IMPLEMENTATION

The test images obtained after thresholding are resized to pixel value of 256 x 256 and converted in to text files.These text files are loaded into a memory by selecting a target device of Spartan-3E FPGA on Xilinx 14.1 platform.The text files of two images of rice grain samples are compared with the text file of reference image.When the pixel values of original image are matched with the pixels values of reference image the output is displayed high as shown in simulated wave forms. The Implementation procedure is shown using block diagram in the Fig 7

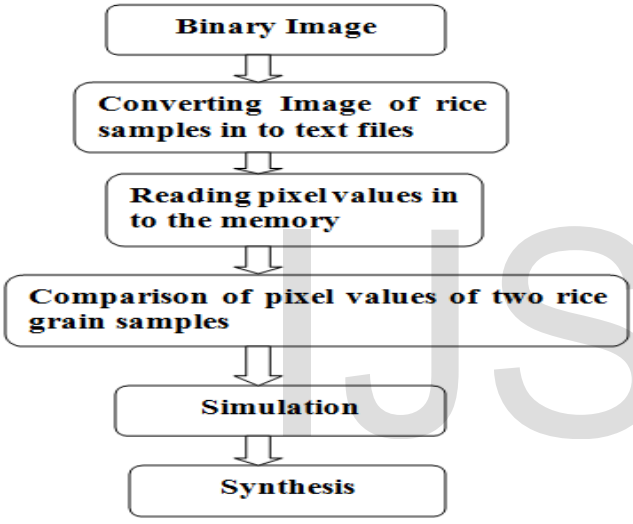
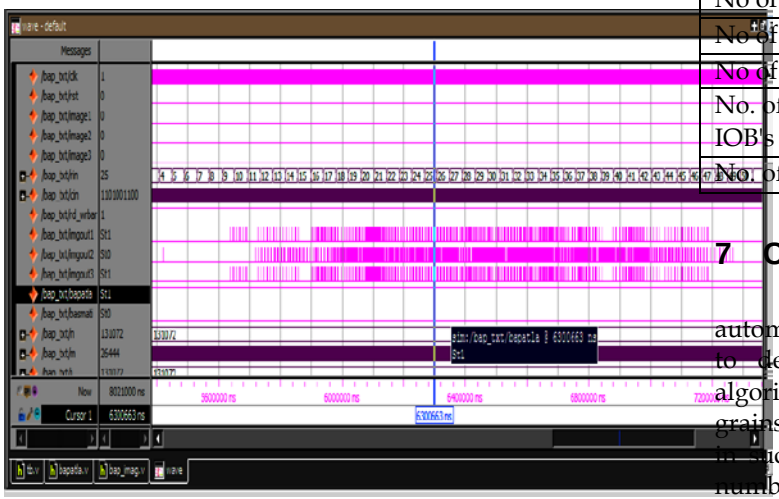


Fig 7 Block diagram of Implementation

The veilog implementation is done using Modelsim-Altera and simulated waveforms are observed.The following Fig 8 and Fig 9 shows the simulation results of detecting rice sample.



Rice grain Variety	No. of iterations the image tested	No. of times the image detected accurately	Percentage of detecting each rice grain sample
Bapatla	6	6	100%
Basmati	6	5	91.6%
Kholam	6	6	100%
Rawrice	6	6	100%
Sonamasuri	6	5	91.6%

Figure-8. Simulation results

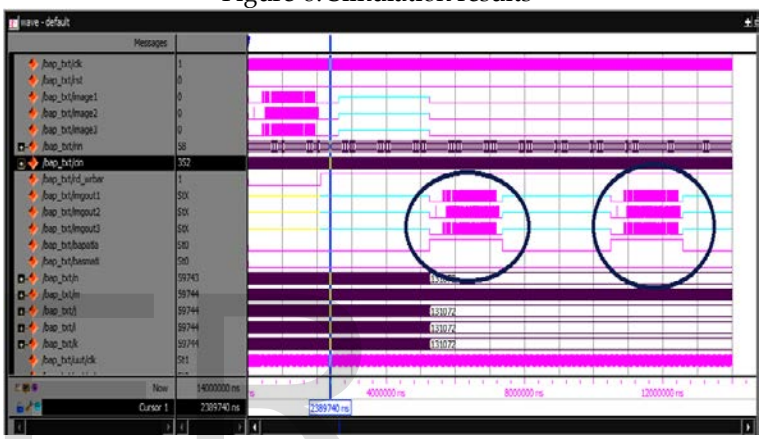


Figure-9 Simulated results of detecting rice grain sample.

The synthesis is done on Xilinx ISE 14.1 by selecting a target device Spartan-3E FPGA.The synthesis report of device utilization is shown in Table-3.

Table-3 Synthesis report of Implementation

Device Utilization			
Logic Utilization	Used	Available	Utilization
No of Slices	160	4656	3%
No of slice FF's	169	9312	1%
No of 4 I/p LUT's	253	9312	2%
No. of Bonded IOB's	4	232	1%
No. of BUFG	1	32	3%

7 CONCLUSION

In this to save lot of time and human effort an automated Image processing technique was implemented to detect and classify the rice grain samples. The algorithm implemented is independant of number of rice grains taken as samples.Hence the algorithm is designed in such a way that it can adjust itself according to the number of rice grain samples given and then 13 quality

features like area, perimeter, boundingbox, equidiameter, length, width, rectangular aspect ratio, major axis length, minor axis length, aspect ratio, solidity are extracted and their mean values are studied.From the obtained results the accuracy of classifying the rice grain samples was 90% - 100% and is suitable to classify large number of samples of rice grains efficiently.

The pixels of two rice grain sample images are compared and detected on verilog platform and the simulated waveformes are observed and analyzed.The synthesis was done on Xilinx ISE 14.1 and implemented using a target device Spartan-3E FPGA.

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