CLASSIFICATION AND DETECTION FOR COFFEE BEANS GRADING BASED ON INDONESIAN NATIONAL STANDARDS THROUGH A SMART COMPUTER VISION BASED ON A RESNET-50 PRE-TRAINED MODEL

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I. INTRODUCTION AND COFFEE BEANS INDONESIAN NATIONAL STANDARD (SNI) 01-2907-2008

Indonesia is the world's fourth-largest producer of coffee beans in 2020, with a total harvest of 1.25 million tons in that year [1]. The harvest is predominantly composed of robusta varieties, accounting for 72.7% of the total [2]. Quality testing based on the types of defects specified in SNI 01-2907-2008 is still conducted visually and organoleptically under natural light by certified testers [3]. This testing process is time-consuming and can cause fatigue among the testers, potentially leading to inconsistencies in the quality of the coffee beans to be traded [3, 4].

Furthermore, algorithms for smart computer vision systems have not been developed to date for testing coffee bean quality based on SNI 01-2907-2008. Hence, one of the objectives of this research is to develop a smart computer vision system using the pre-trained ResNet-50 model to classify, detect types of defects in coffee beans, and assess their grade based on the categorization in SNI 01-2907-2008.

$$\text{Grade} = \frac{\sum score\ of\ defect}{\sum total\ number\ of\ coffee\ beans}$$

References

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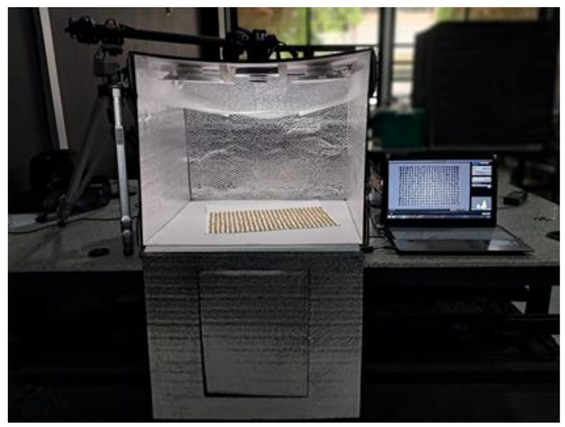
	Grade
Grade 1	0 - 0,009
Grade 2	0,01 - 0,02
Grade 3	0,03 - 0,035
Grade 4a	0,036 - 0,048
Grade 4b	0,049 - 0,064
Grade 5	0,65 - 0,12
Grade 6	0,121 - 0,18

II. IMAGE ACQUISITION

Consistent lighting and proportional field of view selection are important aspects of this research because both variables can affect the accuracy of classification and detection results from the developed smart computer vision algorithm and model [5, 6].

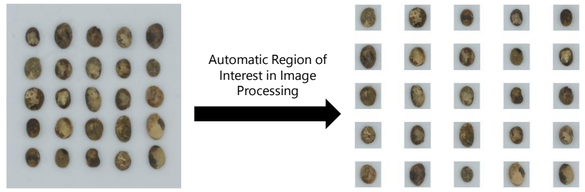


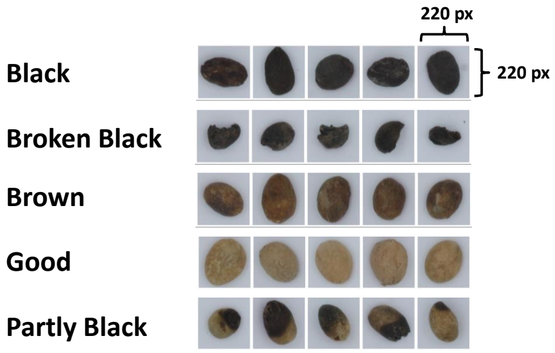
Canon 450D
1/60s exposuretime
F/25 f-number
ISO400
Resolution 4272 x 2848

Lighting uses 6500K LEDs, lighting coverage ± 12000 lux.

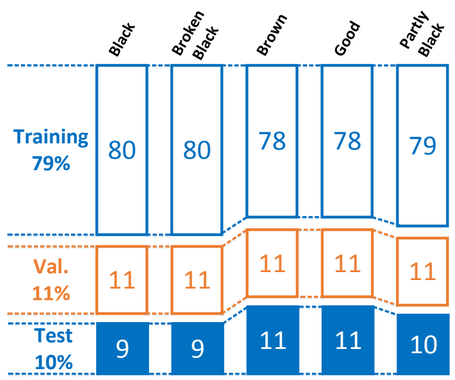
III. IMAGE PREPROCESSING FOR COLLECTING AND SPLITTING DATASET

Images of each defect type underwent preprocessing, including conversion to grayscale, segmentation, centroid determination, and image cropping per coffee bean with a resolution of 220 x 220 pixels.



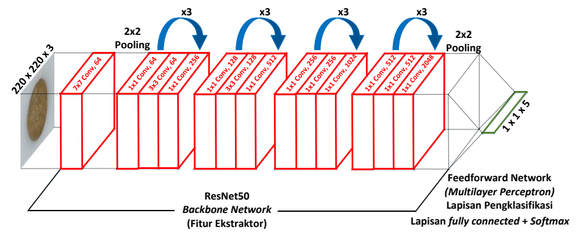


Images per coffee bean were obtained using a programmed iteration algorithm during preprocessing, resulting in a training subset of 395 images or 79% of the dataset, a validation subset of 55 images, and a test subset of 50 images.



IV. COFFEE BEAN IMAGE TRAINING

Training was performed on the convolutional neural network ResNet-50 pre-trained model with a batch size of 32 and 30 epochs using an NVIDIA GeForce RTX 3060 Ti graphics card.



V. VALIDATION, TESTING, AND IMPLEMENTATION RESULT

The result in classification accuracies of 94% and 88% on the validation and test subsets, respectively. The pre-trained ResNet-50 model was then implemented in the developed algorithm for testing the quality based on SNI 01-2907-2008 using coffee bean images not included in the dataset. The reported results showed one detection error in good beans being classified as brown beans, emphasizing the earlier findings that optimal model generalization can be achieved with a larger quantity of dataset images for each defect type, exceeding 100 images per type [7, 8].