Impurity Profiling Of Food Using Template Matching

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***Abstract*— Food is essential for nourishment and sustenance of life. The addition of impurities to food affects the composition and quality of food. The manual method is practical and fast, but lacks the reliability and objectivity required in competitive food industries. Machine vision using morphological features have been reported in numerous studies as an effective solution to detect impurities in food. In this paper we experimented detection of impurities in rice samples using template matching technique. Various image processing techniques have been studied and we've concluded that template matching is the best and efficient way to detect the impurities. Using area computation we've also identified the broken rice in samples.**

***Index Terms*— Machine vision, Edge Detection, Normalized Cross Correlation, Template Matching**

I. INTRODUCTION

Agriculture is Indian economy's mainstay and it comprises 18.5% of the GDP (gross domestic products). Due to the advancement in cultivation technology, the total cultivation areas and yields for agricultural products have increased rapidly in recent years, generating tremendous market values. In the last 2 years agriculture and its allied sectors have registered note worthy growth rate of 4% as opposed to the average annual growth rate of 2.5%. India's fruits and vegetables production is registering year on-year growth and touching a new height. It has produced 197.54 million tons (68.47 MT fruits and 129 MT vegetables), 27.72 millions tons oilseed, 7.64 million tons fish and 556,280 millions numbers of eggs. However this is indicating vast potential for India to emerge as a major exporter of agricultural products, its share in global market is very low due to very high post harvest losses in handling and processing, mismanagement of trades and procurements, lack of knowledge of preservation and quick quality evaluation techniques.

Furthermore, the ever-increasing population and the increased expectation of food products of high quality and safety standards, there is a need for the growth of accurate, fast and objective quality determination of food and agricultural products. However, ensuring product quality is one of the most important and challenging tasks of the industries before export of food and agricultural produce.

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At the current stage, the quality has been assessed traditionally by hand [4], inspecting the products individually or sampling large batches which is very time consuming and inconsistent. The inspection is performed by personnel trained to detect defects, colors, sizes or strange features, and classify the product in its appropriate category. The enormous variability that can present this type of products in terms of colors, textures or different types of defects, hinders their classification, being machine vision, a valid alternative to automate this task. Automation means every action that is needed to control a process at optimum efficiency as controlled by a system that operates using instructions that have been programmed into it or response to some activities. Since automated systems are faster and more precise, the automatic qualitative inspections on food and agricultural products have been attracted much interest and reflected the progress of machine vision applications. Now, applications of these techniques have been widely used for shape classification, defects detection, and quality grading and variety classification etc.

Quality of rice [4] is not always easy to define as it depends on the consumer and the intended end use for the grain. All consumers want the best quality that they can afford. As countries reach self-sufficiency in rice production, the demand by the consumer for better quality rice has increased. Traditionally, plant breeders concentrated on breeding for high yields and pest resistance. Recently the trend has changed to incorporate preferred quality characteristics that increase the total economic value of rice. Grain quality is not just dependent on the variety of rice, but quality also depends on the crop production environment, harvesting, processing and milling systems.

The next of this paper is organized as follows. Section 2 deals with noise rejection technique. Section 3 outlines the Machine Vision System. Edge Detection Techniques have been discussed in Section 4. Section 5 deals with Normalized Cross Correlation functionality. Template Matching technique is dealt in Section 6.Section 7 contains Procedure for Broken Rice Detection. Finally Section 8 contains the concluding remarks.

II. NOISE REJECTION

Salt-and-pepper noise [13] is a special case of impulse noise, where a certain percentage of individual pixels in digital image are randomly digitized into two extreme intensities. Normally, these intensities being the maximum and minimum intensities, the contamination of digital image by salt-and-pepper noise is largely caused by error in image acquisition and/or recording. For example, faulty memory locations or impaired pixel sensors can result in digital image being corrupted with salt and pepper noise. To get rid of such real world problem different methods have been proposed. A variety of methods have been recently proposed in the literature which are able to perform detail-preserving smoothing of noisy image data yielding better results than classical operators. In traditional median filtering called standard median filter (SMF), the filtering operation is performed across to each pixel without considering whether its contamination status. So, the image details contributed by the corrupted pixels are also subjected to filtering and as a result the image details are lost in the restored version. To alleviate this problem, an impulse noise detection mechanism is applied prior to the image filtering. In switching median filters, a noise detection mechanism has been incorporated so that only those pixels identified as corrupted would undergo the filtering process, while uncorrupted ones are kept intact. The progressive switching median filter (PSMF) [14] was proposed which achieves the detection and removal of impulse noise in two separate stages. In first stage, it applies impulse detector and then the noise filter is applied progressively in iterative manner in the second stage. In this method, impulse pixels located in the middle of large noise blotches can also be properly detected and filtered. This method shows better result up to 60% noise, but the performance drastically reduced beyond it due to use of fixed window size. Adaptive median filter (AMF) [13] is used for discriminating corrupted and uncorrupted pixels and then applies the filtering technique.

Noisy pixels are replaced by the median value, and uncorrupted pixels are left unchanged. AMF performs well at low noise densities but at higher noise densities, window size has to be increased to get better noise removal which will lead to less correlation between corrupted pixel values and replaced median pixel values. This leads to degradation of fine details such as edges in filtered image for highly corrupted image, i.e. beyond 70% noise. A decision-based algorithm (DBA) uses a fixed window size of 3 x 3, where the corrupted pixels are replaced by either the median pixel or neighborhood pixels. It shows promising result with lower processing time which degrades the visual quality of the image as the noise density increased. To overcome this problem, an improved decision-based algorithm (IDBA) [15] is proposed where corrupted pixels can be replaced either by the median pixel or, by the mean of processed pixels in the neighborhood. It results in a smooth transition between the pixels with edge preservation and better visual quality for low-density impulse noise. The limitation of this method is that in the case of high- density impulse noise, the fixed window size of 3 x 3 will result in image quality degradation due to the presence of corrupted pixels in the neighborhood. It can give the acceptable result up to 80% noise. The FBDA [13] is an improved fuzzy-based switching median filter in which the filtering is applied only to corrupted pixels in the image while the uncorrupted pixels are left unchanged. During the time of filtering process FBDA selects only uncorrupted pixels in the selected window based on a fuzzy distance membership value.

III. MACHINE VISION SYSTEM

Machine/computer vision is a relatively young discipline with its origin traced back to the 1960 s. Sonka et al.[2] reported that more than 1,000 papers are published each year in the expanding fields of computer vision and image processing. Machine vision is an engineering technology that combines mechanics, optical instrumentation, electromagnetic sensing, digital video and image processing technology. As an integrated mechanical-optical-electronic-software system, machine vision has been widely used for examining, monitoring, and controlling a very broad range of applications. It is the construction of explicit and meaningful descriptions of physical objects from images and it encloses the capturing, processing and analysis of two-dimensional image .However, in another study by Sonka et al. [2] noted that it aims to duplicate the effect of human vision by electronically perceiving and understanding an image, and provides suitably rapid, economic, consistent and objective assessment .So, it could be said that the machine vision is the use of devices for optical, non-contact sensing to automatically receive and interpret the image of a real scene in order to obtain information and control machines or process image. Nevertheless we can say that the computer vision technology not only provides a high level of flexibility and repeatability at a relatively low cost, but also, and more importantly, it permits fairly high plant throughput without compromising accuracy. Applications of these techniques have now expanded to various areas such as medical diagnostic, automatic manufacturing and surveillance, remote sensing, technical diagnostics, autonomous vehicle, robot guidance and in the agricultural and food industry, including the inspection of quality and grading of fruit and vegetable. The food industry continues to be among the fast growing segments of machine vision systems. It has also been used successfully in the analysis of grain characteristics and in the evaluation of foods such as potato chips, meats, cheese and pizza. Crowe and Delwiche [2] have developed a machine vision system for sorting and grading of fruits based on color and surface defects. Tao et al. and Tao have developed a high capacity color vision sorter based on optical properties such as reflectance to determine color , shape, size, textural feature, volume and surface area of fruits and vegetables including apples, peaches, tomatoes and citrus. Computer vision systems provide suitably rapid, economic, consistent and objective assessment; they have been used increasingly in the food and agricultural industry for inspection and evaluation processes. They have proved to be successful computer vision system for the objective measurement and assessment of several agricultural products. Over the past decade advances in hardware and software for digital image processing have motivated several studies on the development of these systems to evaluate the quality of diverse and processed foods. Computer vision has long been recognized as a potential technique for the guidance or control of agricultural and food processes. The majority of these studies focused on the application of computer vision to produce quality inspection and grading. Traditionally, quality inspection of agricultural and food products has been performed by human graders. However, in most cases these manual inspections are time consuming and labor-intensive. Moreover the accuracy of the tests cannot be guaranteed. By contrast it has been found that computer vision inspection of food products was more consistent, efficient and cost effective. Also with the advantages of superior speed and accuracy, computer vision has attracted a significant amount of research aimed at replacing human inspection. Recent research has highlighted the possible application of vision systems in other areas of agriculture, including the analysis of animal behavior, applications in the implementation of precision farming and machine guidance , forestry and plant feature measurement and growth analysis .Besides the progress in research, there is increasing evidence of computer vision systems being adopted at commercial level. This is indicated by the sales of ASME (Application Specific Machine Vision) systems into the North American food market, which reached 65 million dollars in 1995 . Graves and Batchelor summarized more than 20 machine vision applications that were classified by tasks in the natural product industry, more than 15 in manufacturing industry, and seven other machine vision tasks applied to various situations such as security and surveillance, medicine and health screening, military, and traffic control and monitoring. Gunasekaran reported that the food industry is now ranked among the top ten industries using machine vision technology.

This paper with the help of machine vision technology identifies the impurities in food samples using template matching technique. After studying various techniques to detect the impurities in rice samples template matching technique was found to be the best to detect the impurities.

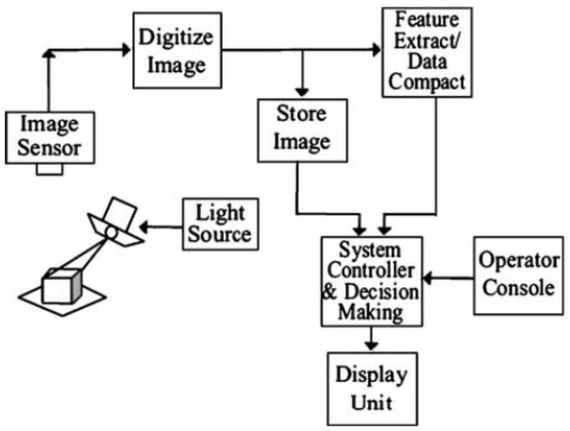


Fig.1.Machine Vision System

IV. EDGE DETECTION

Edge detection is an essential tool for machine vision and image processing. In image processing, an edge is the boundary between an object and its background. They represent the frontier for single objects. Therefore, if the edges of object's image can be identified with precision, all the objects can be located and their properties such as area, perimeter, shape, etc., can be calculated. It is also the process of locating edge pixels and increasing the contrast between the edges and the background (i. e. edge enhancement) in such a way that edges become more visible. In addition, edge tracing is another terminology used by researcher, includes the process of following the edges, usually collecting the edge pixels into a list . Some of the well-known edge detectors that have been widely used are the Sobel, Prewitt, Roberts, and Kirsch detectors. The first quantitative measurements of the performance of edge detectors, including the assessment of the optimal signal-to-noise ratio and the optimal locality, the maximum suppression of false response, were performed by Canny, who also proposed an edge detector taking into account all three of these measurements. The Canny edge detector was used in the food industry for boundary extraction of food products.

A. Canny Edge Detection:

The Canny edge detector is an edge detection operator to detect a wide range of edges in images.

The algorithm runs in 5 separate steps:

1. Smoothing: Blurring of the image to remove noise.
2. Finding gradients: The edges should be marked where the gradients of the image has large magnitudes.
3. Non-maximum suppression: Only local maxima should be marked as edges.
4. Double thresholding : Potential edges are determined by thresholding.
5. Edge tracking by hysteresis: Final edges are determined by suppressing all edges that are not connected to a very certain (strong) edge.

B. Sobel Edge Detection:

The Sobel operator is used in image processing, particularly within edge detection algorithms. Technically, it is a discrete differentiation operator, computing an approximation of the gradient of the image intensity function. At each point in the image, the result of the Sobel operator is either the corresponding gradient vector or the norm of this vector. The Sobel operator is based on convolving the image with a small, separable, and integer valued filter in horizontal and vertical direction and is therefore relatively inexpensive in terms of computations. On the other hand, the gradient approximation that it produces is relatively crude, in particular for high frequency variations in the image.

C. Prewitt edge detection:

A variety of Edge Detectors are available for detecting the edges in digital images. However, each detector has its own advantages and disadvantages. The basic idea behind edge detection is to find places in an image where the intensity changes rapidly. Based on this idea, an edge detector may either be based on the technique of locating the places where the first derivative of the intensity is greater in magnitude than a specified threshold or it may be based on the criterion to find places where the second derivative of the intensity has a zero crossing. The basic criterion for using Prewitt edge detector for detection of edges in digital images is that image should contain sharp intensity transition and low noise of Poisson type is present. When using Prewitt edge detection the image is convolved with a set of (in general 8) convolution kernels, each of which is sensitive to edges in a different orientation.

D. Robert edge detection:

The Roberts operator performs a simple, quick to compute, 2-D spatial gradient measurement on an image. It thus highlights regions of high spatial gradient which often corresponds to edges. In its most common usage, the input to the operator is a grayscale image, as is the output. Pixel values at each point in the output represent the estimated absolute magnitude of the spatial gradient of the input image at that point.

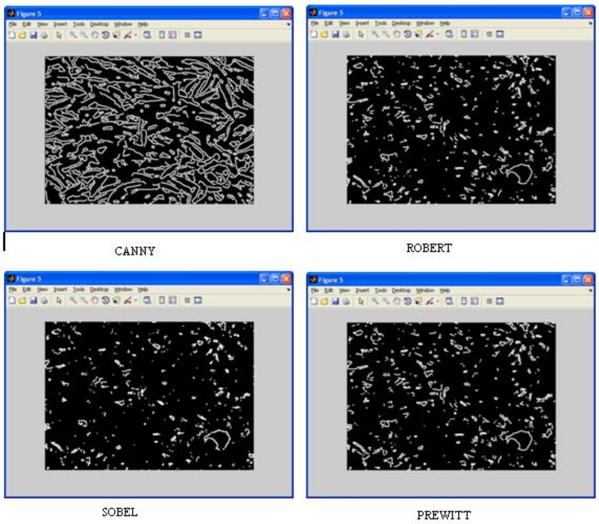


Fig.2 Result of edge detection techniques

V. NORMALIZED CROSS CORRELATION

Local image matching (block-matching) is a frequent operation in many image processing tasks, such as MPEG compression and the estimation of optical flow and stereo disparities. Normalized cross-correlation (NCC) [3] is particularly useful since it is insensitive to both signal strength and level.

Normalized cross correlation (NCC) [3] has been commonly used as a metric to evaluate the degree of similarity (or dissimilarity) between two compared images. The main advantage of the normalized cross correlation over the cross correlation is that it is less sensitive to linear changes in the amplitude of illumination in the two compared images. Furthermore, the NCC is confined in the range between –1 and 1. The setting of detection threshold value is much easier than the cross correlation. The NCC [3] does not have a simple frequency domain expression. It cannot be directly computed using the more efficient FFT (Fast Fourier Transform) in the spectral domain. Its computation time increases dramatically as the window size of the template gets larger. Correlation-based methods have been used extensively for many applications such as object recognition, face detection motion analysis and industrial inspections of printed-circuit boards, surface-mounted devices, wafers, printed characters, fabrics, ceramic tiles, etc. The traditional normalized correlation operation does not meet speed requirements for industry applications. In this paper, we use a fast normalized cross correlation method for defect detection.

In object recognition or pattern matching applications, one finds an instance of a small reference template in a large scene image by sliding the template window in a pixel-by-pixel basis, and computing the normalized correlation between them. The maximum values or peaks of the computed correlation values indicate the matches between a template and sub images in the scene.

Typically block-matching [3] is done by comparing a block with a number of blocks within a region in another image. The block in the search region with the highest correspondence value is selected as the matching block. There are several ways to measure the correspondence between two blocks. Cross-correlation gives a robust and dense measure of the correspondence between two blocks. In particular if you normalize the cross-correlation in terms of mean and variance you will get a correspondence measure that is insensitive to luminance scale and level. Burt et al showed in a comparison that the normalized cross-correlation consistently gave the lowest error rates compared to non- or partially normalized Laplacian filter. Block-matching requires extensive computations and there exists several algorithms to speed it up, e.g. by reducing the number of blocks to compare with by using different search strategies, and by using pyramid representations and do the search in a coarse-to-fine way. Some work has also been done in optimizing the calculation procedure itself.

VI. TEMPLATE MATCHING

Template matching [5] is commonly used in many computer vision applications such as feature-based tracking, object recognition and stereo-matching. Templates can either be learned from exemplar images or created from models.

Template matching is the classification of unknown samples by comparing two known prototypes or templates. There are two common scenarios:

Search: A search for occurrences of a single template in an image.

Classification: Classification of a sample extracted from an image as one of a number of template prototypes.

Template matching is one of the simplest image detection methods. The

The idea is to slide an image template (binary shapes, or gray level patterns)over the image at hand (a 2D search) to see if an image object matching the template can be found somewhere in the image.

Matching methods [5] differ according to the type of features used: edge pixels, intensity image patches and wavelets coefficients to name a few. In general template matching requires similarity measures between the features of a template and the query image. Image intensity patches are often compared by normalized cross-correlation whereas Hausdorff [5] and chamfer measures are popular with edge-based features. For object detection, template matching is performed by matching the template at all locations, scales and orientations. If the likelihood value, obtained from one or several of the matching measures, is above a threshold, then a possible matching of the template is reported. Such methods ignore the necessity for normalizing the likelihood values and bias towards likelihoods with large partition function values.

Now we have compared a template with the samples using template matching algorithm. This template matching is based on cross-correlation. Cross-correlation can be seen as a measure of similarity of two images. It is also known as a sliding dot product or inner-product.

Methods that exhaustively search a template in an image are one of the oldest computer vision algorithms used to detect an object in an image. However, the mainstream vision community has abandoned the idea of an exhaustive search as there are two prejudices that are commonly articulated. First, that object detection based on template matching is slow and second, that object detection based on template matching is certainly extremely inefficient for, e.g., perspective distortions where an 8 dimensional search space must be evaluated. In our work, we address these issues and show that with several contributions it is possible to benefit from the robustness and accuracy of template matching even when an object is perspectively distorted. Furthermore, we show in a number of experiments that it is possible to achieve an interactive rate of detection that was only possible with a descriptor-based approach until now. In fact, if the overall search range of the pattern is restricted, real-time detection is possible on current standard PC hardware. Furthermore, as we have an explicit representation of the geometric search space, we can easily restrict it and therefore use the proposed method for high-speed tracking. This is in strong contrast to many other approaches , in which a difficult decision has to be made when to switch between a detection and a tracking algorithm. The design of this metric determines the overall behavior and its evaluation dominates the run-time.

VII. BROKEN RICE DETECTION

The quality of the world's most important staple food [4] crop can be determined based on the shape size and texture of the grain. In India the ever increasing population losses in handling and processing and the increased expectation of food products of high quality and safety standards there is need for the growth of accurate fast and objective quality determination of food grains. Nowadays the chemical methods are being used for the identification of broken rice grain seed varieties and quality. The chemical method used also destructs the sample used and is also very time consuming method. On the other hand the machine vision or the digital image processing is a non destructive method, it is also very fast and cheap process compared to the chemical method. In the early days of machine vision application to grain quality evaluation, Lai et al. suggested some pattern recognition techniques for identifying broken rice. The same researchers also applied the digital image analysis technique to discriminate wheat classes and varieties. Particle size distribution [4] and shape analysis is required in several areas that deal with granular or particulate materials. Bulk properties of such materials are of importance and variations in the size and shape of particles can result in significant change in their properties and/or value. Image processing is a common tool for applications in particle characterization, metallurgy, agriculture, biotechnology, etc. Digital imaging systems have found increasing use in such analyses as they are economical, fast and accurate. One of the areas of digital imaging applications is in testing the quality of food materials. Image analysis systems for food materials are not only efficient but also non-destructive in sample handling. Brosnan [4] and Sun have reviewed the use of computer vision systems in the agricultural and food industry. They have discussed areas like assessment of fruits, vegetables and nuts, as also the successful use of computer vision systems in the analysis of grain characteristics and the evaluation of foods such as meats, cheese and pizza. Digital image analysis has also been used to evaluate the effect of moisture content on cereal grains by studying its effect on the physical appearance and kernel morphology.

For efficiency reasons there shouldn't be broken rice particles in the rice packs. So we scatter the rice so that one rice particle doesn't touch another and take pictures of images. These are the samples that we're going to examine. These are the steps that are followed to detect the broken rice.

a) First of all we set the level for the background and then subtract the image from this background. By practicing this we get the more uniform background.

b) Next we convert this image into the binary image For performing other morphological operations.

c) Now the area of a whole rice grain is calculated and its value is kept as the threshold.

d) We find the connected components of our final binary image. By this we get the following information Connectivity, Imagesize, Numobjects, PixelIdxlist about our final binary image. From this we also get the exact number of grain kernels present in our image.

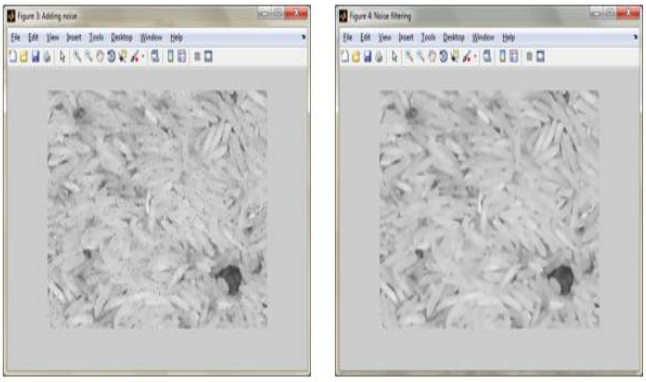
e) After this we find the pixel area of the each grain present in our binary image. Once we have the pixel area of each grain we can find out which grain particle's area is less than the threshold set. Those particles's area that is half less than the threshold is marked with rectangle border.

VIII. IMPLEMENTATION

This project is going to be done in MATLAB 2010.The preprocessing for an image is removing noise. Our images don't have noise. So we've added noise to it and removed it based on the Improved Decision Based Algorithm that we've proposed. The Next step taken is edge detection. Edge Detections have been performed on the sample images and it did not give the expected result. The edges were not detected properly. Hence we go for Template Matching technique. For this normalized correlation is performed and with that result we match the templates that we've collected for the sample images. When templates are matched with the sample image we get the defects or impurities present in the image. For several images this is done and the impurities are detected successfully.

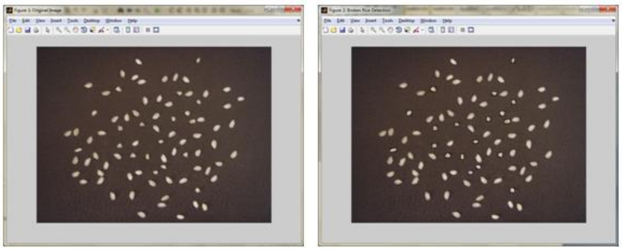
For Broken Rice Rejection various samples are collected. Then the area of a whole rice grain is calculated. Half of this area is kept as the threshold and the rice particles that have area less than this threshold are detected as the broken rice. For all these broken rice particles a rectangle border is given which gives the exact position of these particles.

In Template Matching, the templates of the impurities are collected and stored. Then the stored templates are compared with the captured rice images to identify any matches present. If a match is found, the impurity will be detected as shown in Fig.4.



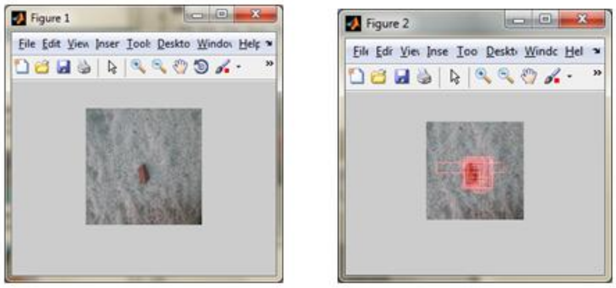
After Adding Noise | After Removing Noise

Fig.4. Noise Rejection



Sample Image | After identifying broken rice

Fig.3.Broken rice Detection



Sample Image | After template matching

Fig.4.Template Matching

IX. CONCLUSION

Machine vision systems have been used increasingly in industry for inspection and evaluation purposes as they can provide rapid, economic, hygienic, consistent and objective assessment. However, there are some difficulties still existing in the adaptation of machine vision system, evident from the relatively slow commercial uptake of machine vision technology in all sectors. At the end, we can say that machine vision is a powerful tool of automation that includes both image processing and image analysis tools. All consumers want the best quality that they can afford. Template matching is one of the simplest image detection methods. The experiments show that the algorithm is an efficient way of speeding up block-matching with normalized cross-correlation. While significantly reducing the number of calculations the properties of the NCC are preserved. Here, we conclude that purity percentage of rice samples can effectively be done by using the image processing techniques. This is also more accurate than the human visual inspection. All this leads to better quality in food processing by image processing.

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