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Real Time Digital Image Processing System for Quality Control in Paper Manufacturing Industry

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Abstract: *Evaluation of surface quality is an essential aspect in part assembly and functioning performance. In this research the development of quality inspection system for paper mill finishing lines is presented. The system detects contaminants, adhering paper particles, folded paper defects, and misalignment) of stacks of paper. The construction of Opto-scan system and its working for paper quality control is presented. Experimental investigations reveal that the system can be used to control the quality of high priced and normal papers. Even small colour difference or small roughness variation, contaminants in the papers and their surface can be detected by the use of developed Machine vision and hue threshold method. The system can help to increase the productivity of high quality paper in paper manufacturing industries.*

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I. Introduction

In the recent years [1-2], there has been an increasing interest to manufacture papers having different characteristics for varied usages. Traditionally, assessing surface roughness was performed by tracing the profile by a stylus technique. However, such procedure was mainly, limited to 2D assessment. Automation in manufacturing and minimization of cost through reducing percentage of rejection has forced for high-speed, non-contact and reliable surface roughness assessment. Although many techniques were made available for surface roughness measurements, including the optical techniques, no technique has been established reliable and robust enough for the different applications. An optical technique through image processing is still faces several drawbacks due to the various parameters involved. Capturing an image from a camera requires a source of energy and a sensor array to sense the amount of light reflected by the object generating a continuous voltage signal by the amount of sensed data and converting this data into a digital form through sampling and quantization. Thus both the light intensity and type of the camera may be considered two parameters. Setting the camera (height of the camera and angle of the received rays) with respect to the object are further parameters that may affect the consistency of the results and their accuracies. Image analysis techniques are used in many aspects of engineering works; these techniques have been used in textile and nonwoven technologies to measure and control their different features. Machine vision systems are being used in industrial production for operation of process, automation and quality control [3-5]. Image analysis techniques are used in many aspects of engineering works, these techniques have been used in textile and nonwoven technologies to measure and control their different features. Specifically in nonwovens, image analysis is a quite reliable and reputable technique to measure uniformity, cover factor, surface roughness, etc. Some research topics were dedicated to measuring nonwoven mass uniformity and homogeneity as it plays an important role in these fibrous structures. There are researches were undertaken to analyze structure of nonwoven fabrics using image analysis. Surface roughness is an important technological parameter and indicator of the machined surface quality. Requirements for lower values of surface roughness simultaneously affect the prolongation of machining time and increase of production costs. Surface roughness is conditioned by a larger number of controlled and uncontrolled process parameters (including cutting speed, depth of cut and feed rate, raw material properties, cutting conditions, tool properties, tool machine vibrations, tool wear etc.). By regular monitoring the results of a machining process and expanding the knowledge base about the monitored parameters of observed processes, it is possible to continuously improve a product characteristic and production results.

There is a great number of scientific investigations aimed at prediction and control of surface roughness. The models defined in these investigations can be divided into regression (statistic), analytic (mathematic) and those based on the application of artificial intelligence (AI) [5-8].

It is often the case that the digital image features of the machined surfaces are used in controlling or assessing the machined surface roughness. The image features are used as input variables for the assessing model [9-13], and they are mostly represented by statistic values such as arithmetic mean and standard deviation, different kinds of standards such as the Euclidean and the Hamming norm [14- 15], wave transformations such as the Haar wavelet transform. In this paper we are presenting a new application of machine vision system for paper manufacturing industry.

The paper discusses the construction, working and application of Opto-scan system. The paper also discusses that a small color difference and small even a little variation in the product can be detected.

II. Methods and tools

The contaminants (rope, craft paper, plastic, human hairs, Particles etc.) of few millimeters are placed on the paper. The object (contaminated paper) is illuminated by fluorescent lamp and imaged by CCD camera as shown in fig.1a. The 1b. shows the structured lighting from different angles.The sample papers are Communications paper, Printing and writing paper, Duplex board, packaging materials, and container board, Newsprint, Household paper (tissue, toilet rolls). We have taken the image separately with plane paper and bond paper.

The image of the contaminated paper made by CCD camera is sent to the computer. The program made in Labview graphical programming language based on hue threshold can isolate the plane of contaminant in the image, which gives complete detection of contaminants. The experiment was done with individual contaminants and five contaminants together as shown in fig.3.

1.1 Hardware and Image Analysis

Machine vision system contains three parts -

1. Opto-vision / Opto-scan
2. Image grabbing /processing and
3. Image analysis

The Schematic of the machine vision system is shown Fig.1a and b. It consists of the following hardware and software.

Hardware-

a. Image processing Card IMaq 1408, 8bit monochrome, Image Transfer rate 132 M bytes/s, Image size horizontal 782, Vertical 2048 (maximum)Window size is set- Horizontal-610,Vertical- 540

b. CCD Camera- Resolution-576(H) x 581(V), Cell size – 11x11 μm

d. Programming platform Labview and matlab

1.2 Image grabbing and processing scheme contains following steps -

1. Image grabbing
2. Decomposition of image intensity data in different intervals.
3. Sum of the decomposed data sets.
4. Sum is divided by average value (average corresponds to the intensity of background i.e. light scattered/ reflected by the good paper i.e. paper not having any defect)
5. The resultant is sent to RGB plane to display the defects in paper.

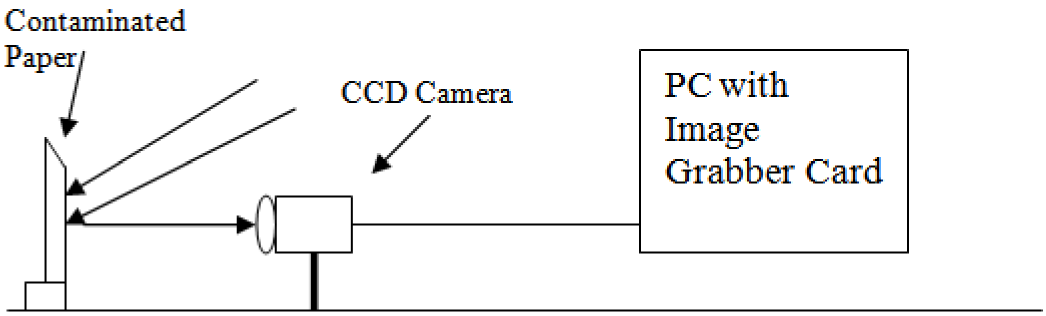


Fig.1a Schematic diagram of the detection system for quality control of papers

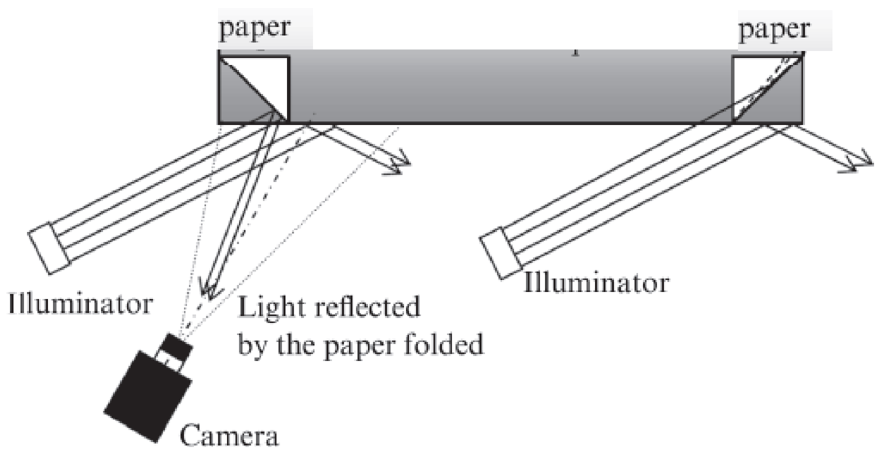


Fig.1b Schematic diagram of the machine vision system for quality control in paper manufacturing industry

Flow diagram for detection of defects in paper is shown in Fig. 2.

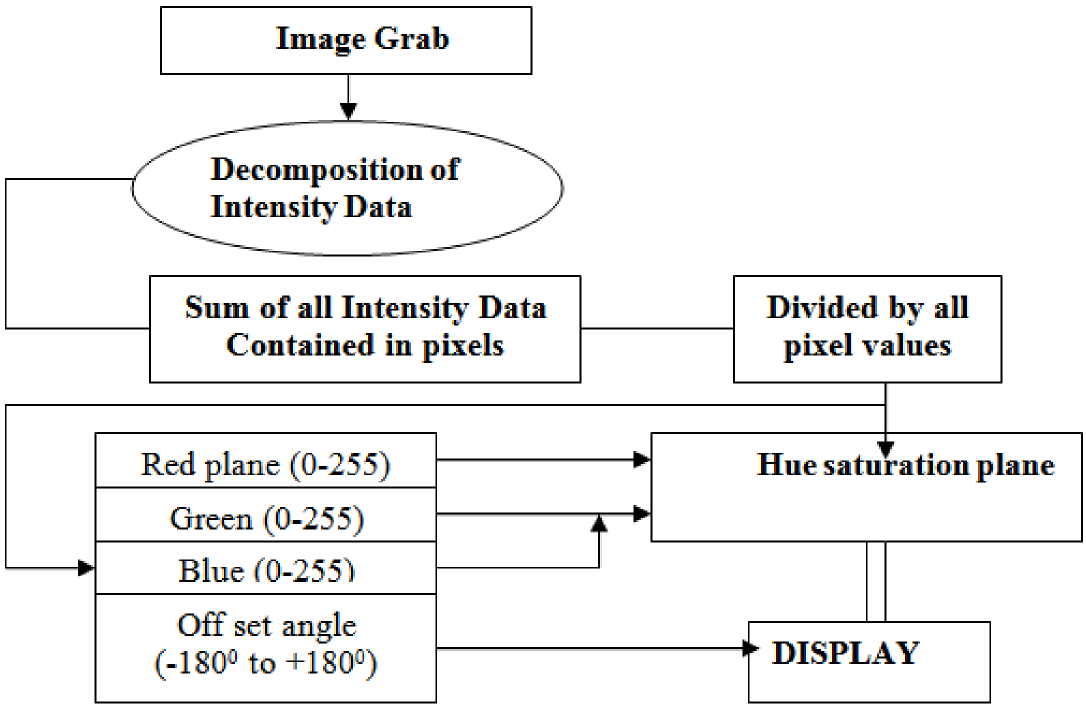


Fig.2 Flow diagram for detection of defects in paper using Image processing system.

III. Description

Texture analysis is needed in day to day applications (industry, medicine, textiles etc[9-15]. Scattered light from the cotton tuft is collected by CCD camera lens and converted to 8-bit gray level image in two dimensional arrays. The image is converted into discrete number of pixels by image grabber and digitizer card. The acquisition device assigns a numeric location to each point in the image which is function of light intensity f (x,y) where f is the brightness of the point (x,y). The x ,y represent the spatial coordinates of a picture element (abbreviated as pixel). It assigns gray level value, which specifies the brightness of pixels. It is processed by digital image processing following the properties: image resolution, image definition, and number of planes. The acquired image is send to Hue saturation plane where it is displayed in Red(R), Green (G) and Blue(B) colors. The RGB plane is 120^0 each with respect to white light. The Flow diagram for detection of defects in paper is shown in fig. 2.

Hue Saturation Value (HSV) Color Model The HSV color space is more intuitive to how people experience color than the RGB color space. As hue (H) varies from 0 to 1.0, the corresponding colors vary from red, through yellow, green, cyan, blue, and magenta, back to red. As saturation(S) varies from 0 to 1.0, the corresponding colors (hues) vary from unsaturated (shades of gray) to fully saturated (no white component). As value (V), or brightness, varies from 0 to 1.0, the corresponding colors become increasingly brighter. The hue component in HSV is in the range 0° to 360° angle all lying around a hexagon as shown figure 3 [3]. With RGB the color will have values like (0.5, 0.5, 0.25), whereas for HSV it will be (30°, √3/4, 0.5). HSV is best used when a user is selecting a color interactively It is usually much easier for a user to get to a desired color as compared to using RGB. The model is shown in figure 3.

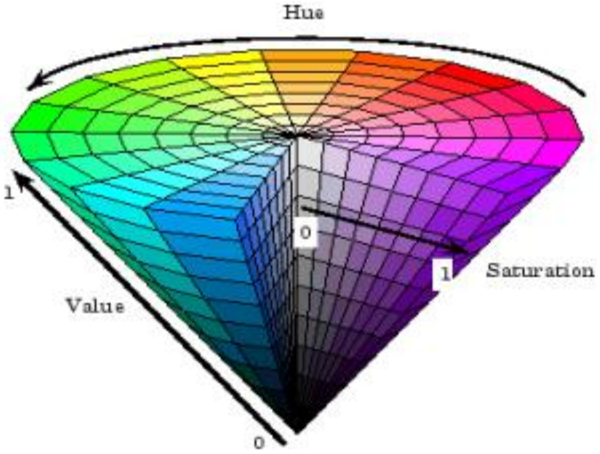


Fig.3: HSV Colour model

IV. Result and Discussion

Structured lighting set up was used to get uniform light distribution on the objects. Large number of experiments was conducted to analyse the working of hardware and software. The Original contaminated image is shown in fig.4 (a) and (c). The detected image is shown in fig.4 (b) and (d). From the results it clear that the hue threshold can completely detects contaminants such as rope, plastic, hairs, craft papers and particles etc. Figure 5 shows the particle detection.

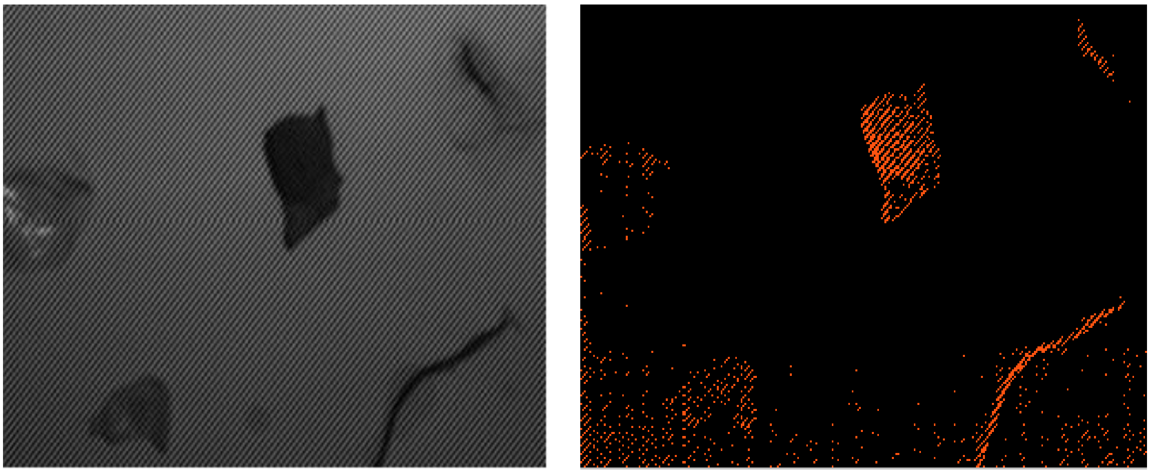
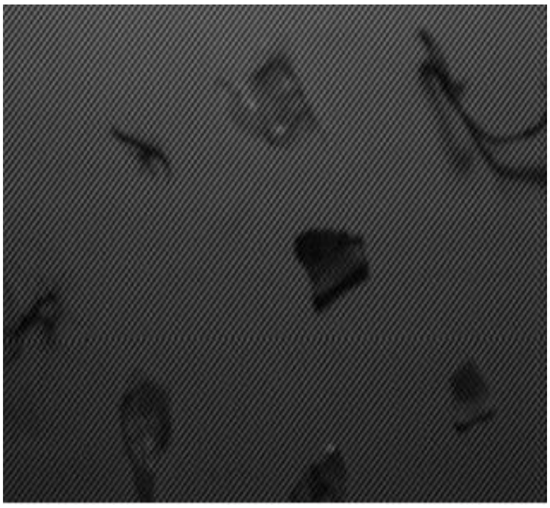
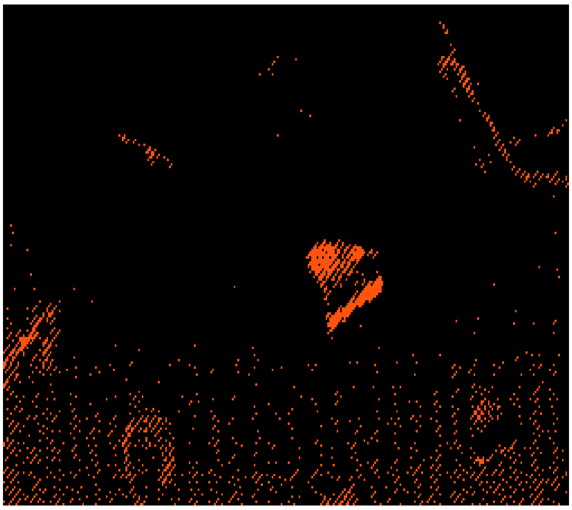


Fig.4.(a) Original image of plane paper With contaminants (b) Contaminants detected from Paper



(c) Original Image Bond paper with contaminants



(d) Contaminants detected image

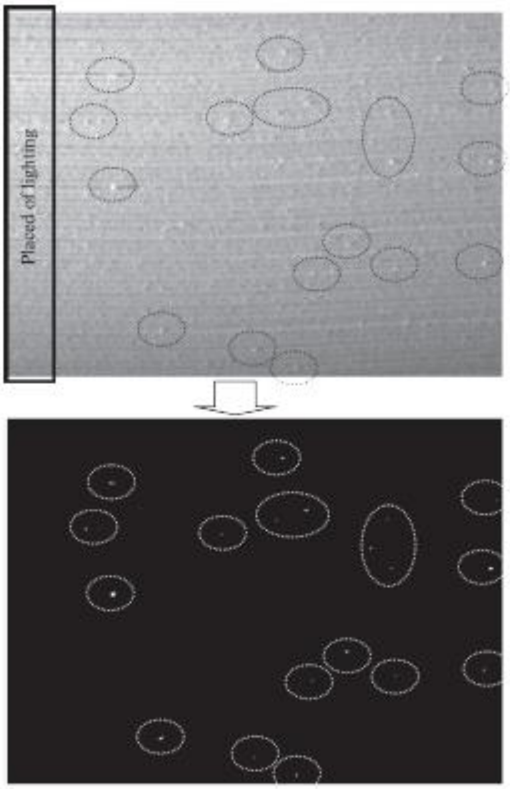


Fig.5: Showing detected surface Particles

IV Conclusion

The paper introduces inspection methods and structure of appearance quality inspection systems for paper mill finishing lines. The main content is summarized below.

(1) A detection method for contaminants mixed in different types of papers is developed..

(2) A method for detecting particles and folds in the stacked edge was explained. In the stacked surface and the plane of the paper, the reflection of illuminated light is different. By using this difference, a camera/lighting special arrangement is presented to detect a fold appears in the stacked surface.

Surface composition structure is thus one of the most important factors in our perception of paper quality. The profile height of paper surfaces/ structure can be measured by the technique developed.

It is a on line procedure. It can be used in different paper production industries.

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