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Investigation of Surface Texture Using Image Processing Techniques

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Abstract

Surfaces of industrial parts need to be specified based on their utility and application environment. Since the quality of surface influences the suitability of components for a specific application, more attention had been given by researchers to measure the surface quality accurately. Current techniques of quantifying surface quality use profilometers, coordinate measuring machines and some optical techniques. With the advent of automation, surface characterization needs to be totally computerized so that the task of inspection (of surfaces) is greatly simplified and free from human error. In this research paper a methodology is presented that uses a computer vision system to characterize the nature of the surface. Computerized optical microscope will be used to acquire the images of the surface and the same images will be fed into MATLAB software for further investigations. The advantages of using a vision system over other techniques will be adequately discussed.

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Keywords: Surface inspection, Surface metrology, Computer vision.

1. Introduction

Surface finish evaluation is very important to solve many basic fundamental problems such as friction, contact deformation tightness of contact joints and positional accuracy. Therefore, surface roughness and topology has been the subject of experimental and theoretical investigations for last two decades [1,2]. Many techniques have been developed, from the simple comparator to sophisticated optical techniques for measuring surface finish [3]. In recent years, the advent of high-speed general-purpose digital computers and vision systems has made image analysis easier and more flexible [4,5]. Moreover, Computer vision techniques have received increasing attention for measuring surface roughness by many researchers [6–10]. The term texture analysis is considered as a basic issue in image processing and computer vision; therefore, it has been an active research topic for more than three decades. Basically, surface finish measurements can be divided into two approaches: direct and indirect contact methods. Direct contact method depends on using stylus instruments, which require direct contact with the surface to be investigated. Stylus instruments have limited flexibility in handling the different geometrical parts to be measured

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[10,11]. In addition to this, measurement speed of the stylus instrument is also slow. In contrast, the indirect method uses optical instruments which are inherently noncontact measurements and easy to automate. In this paper, an indirect method using computer vision for inspecting surface finish has been developed and its capability is being investigated experimentally.

2. Experimentation

2.1. Preparation of work piece material

In this work, a stainless steel grade 316L material is used for conducting the surface finish studies due to its wide range of application in the medical field, pharmaceutical and photographic equipment where the high surface finish is mandatory. To prepare the work piece for the experiment, a rough grinding operation is made on the work piece with the depth of cut of 0.1mm. After the grinding process the specimen is cleaned with acetone for removing impurities from the surface. Subsequently, the surface roughness profile of the work material is measured by Mitutoyo surf-test equipment and the arithmetic average roughness (R_a) was found R_a = 0.09 µm.

2.2. Image acquition

A photographic view of the experimental setup for acquiring the surface image of the workpiece is shown in Fig.1 surface image is acquired using a CARL ZEISS IMAGER-A1 AX10 incident light microscope and then transferred to the PC workstation through frame buffers. Microscope's in-build digital camera captures the surface image with 480 × 640 resolution, 1/30 s grabbing speed and 8 bit digital output.

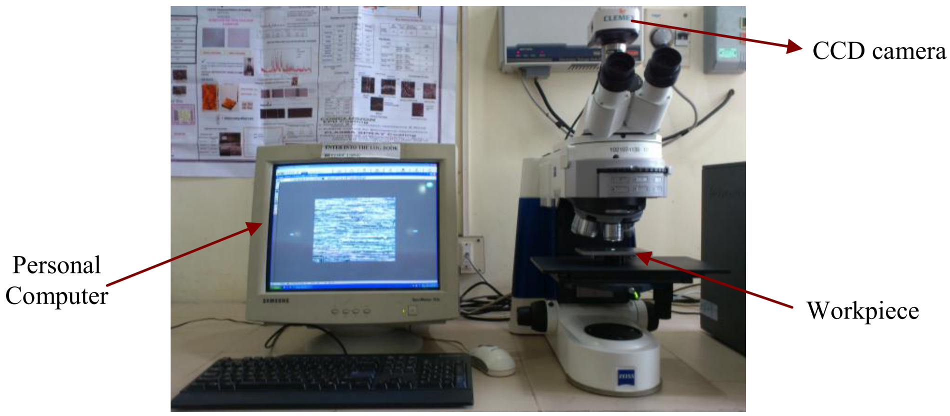

Fig.1. Photographic view of experimental setup

For obtaining the surface image, workpiece kept under the Microscope and the required settings like 100X magnification and focus length are adjusted as per the requirement. Once required portion of surface is reached then the image acquisition software is used to acquire the image. The acquired RGB image is shown in Fig 2.

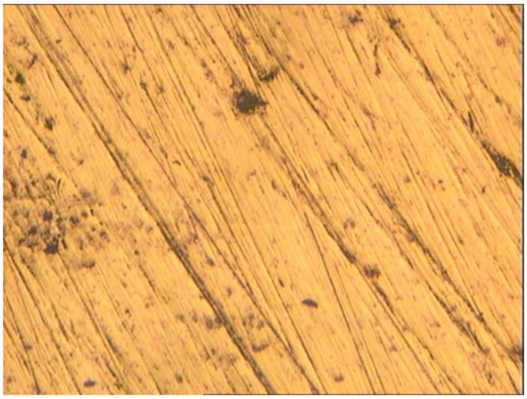

Fig.2. Captured RGB surface image.

2.3. Measuring Procedure

The measuring procedure could be summarized as follows:

i) Capturing a RGB image of the work piece by using the incident light microscope.
ii) Convert the captured image into gray scale image with the range of 0 to 255 scales.
iii) Enhancement of gray scale image by using a histogram sliding.
iv) Use of High pass filter to enhance the edges of the Image for further studies.
v) Calculate the pixel distance between two adjacent deep scratches by using the image tool option.

3. Results And Discussion

3.1. Converting Color image in to Gray scale image

The obtained image is converted into Gray scale level (from 0 to 255) which will be helpful to do the further analysis. By using MATLAB software program the obtained original RGB image is converted in to gray scale image and the corresponding image histogram is obtained to understand the level of pixels in the gray scale image. Fig 3(a) shows the gray scale image obtained after processing the image. Fig 3(b) shows the corresponding Gray Scale image histogram. From the histogram it is found that number of pixels is more (maximum of 6100 pixels) in the gray scale range of 180 to 220. This histogram image indicates that the pixels distribution is not equal at all the points. So the histogram sliding is required to enhance the image for further studies.

Fig.3(a). Gray scale image

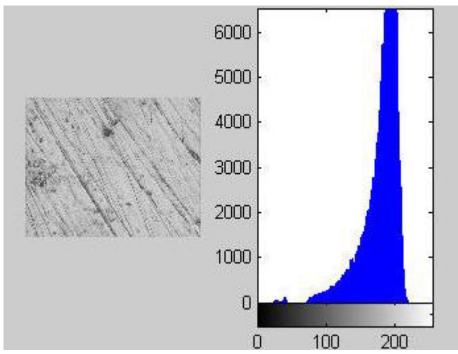

Fig.3(b). Histogram for the Gray scale image

3.2. Enhancement of gray scale image by using histogram sliding.

The obtained gray scale image is further modified by the histogram sliding operation to enhance the captured image. This histogram sliding adds constant brightness to all pixels within the image. It shifts the histogram towards right and increases the brightness of the image. Fig.4 (a) shows the histogram before and after sliding operation and it also shows that after sliding the histogram pixels are distributed from 0 to 255. This will enhance the brightness of the image which is shown in Fig.4 (b).

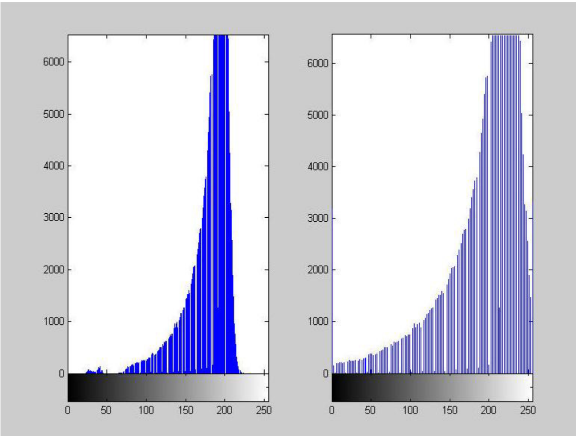

Fig.4(a). Histogram sliding

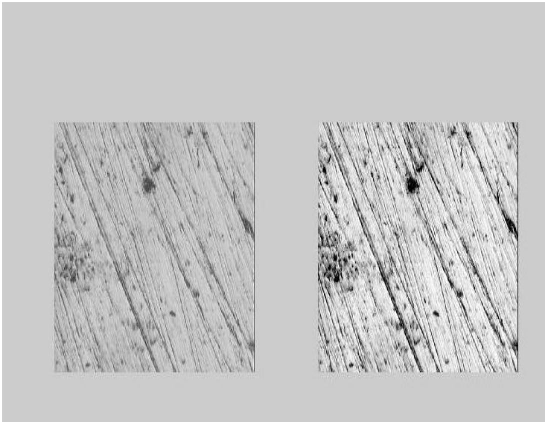

Fig.4(b). Improved Image after histogram sliding

3.3. Enhancement of scratches in the surface using High pass filter.

The image obtained after histogram sliding is further enhanced by eliminating the low frequency components using high pass filter. The high pass filter will not change the high frequency components of a signal and will attenuate the low frequency components as well as eliminate any bias in the signal. As the edges are enhanced using high pass filter the scratches on the surface are visible clearly for the further measurements. Fig 5(a) shows the image before filtering where the scratches on the surface are not predominantly visible. Fig. 5(b) shows the image after filtering where the boundary of scratches is clearly visible.

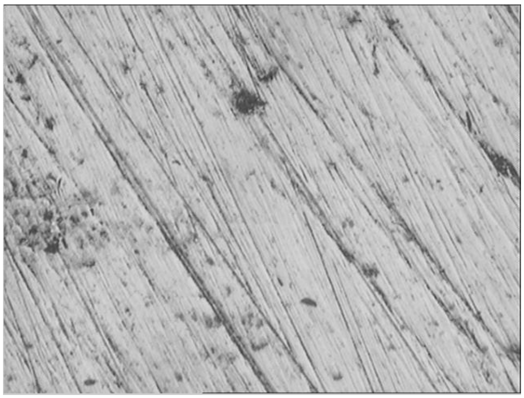

Fig.5(a). image before enhancement of scratches

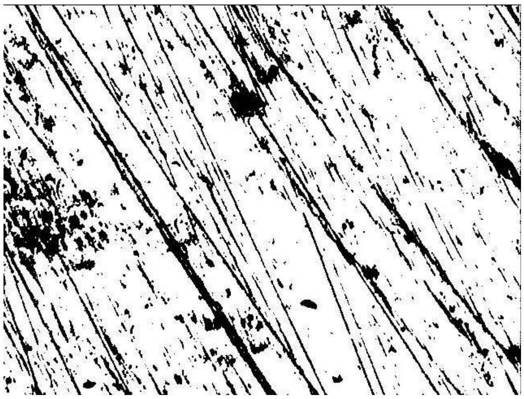

Fig.5(b). image after enhancement of scratches

3.4. Calculation of distance between two neighborhood deep scratches.

Filtering on the image facilitates to find the distance between the adjacent scratches. Image tool of MATLAB is used to find the distance between the scratches. The image tool gives the number of pixels in between any two points on the image. Scratches on the surface of the image are clearly visible after filtering and the image tool is used to get the number of pixels between two deep scratches. The pixel count between two deep scratches gives the distance between them. Fig.6 shows the pixel counts between two deep scratches.

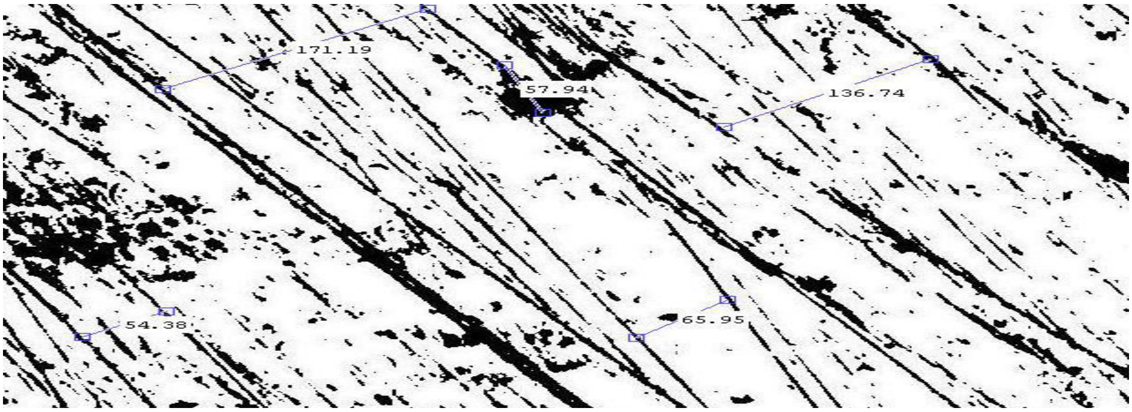

Fig.6 Measurement of Pixel Count between two deep scratches

4. Conclusion:

In this work, a vision based system has been tried for surface texture characterization using the gray scale image approach. Image histogram was analyzed to enhance the image for subsequent investigations. This approach avoids direct contact with the surface to be investigated. Scratches on the surface image are made very clear and the space between them is visible such that the texture of the surface can be easily analyzed. For more utilization of this vision based approach, different filtering approaches may be adopted to improve the accuracy and clarity of the region of interest. This processed image may be used further for calculating the surface roughness value.

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