Automated Calibration Utility for Ruler/Scale Using Moving Digital Camera and Image Processing Algorithms

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Abstract -The proposed system combines a rotary bench with a webcam for calibration of ruler scale length<=15cm.This proposed system provides fast and automatic operation with an economic solution for the calibration problems of ruler scales. In this system webcam is mounted on a rotary nylon rod along with the standardized test scale. For linear motion of camera nylon rod is rotated by using stepper motor. This configuration setup provides linear motion to camera from right to left or vice versa along the length of scale. Camera captures the images of whole length of test scale at the fix time intervals. Both linear and rotary motion of webcam gives the capability to take precise images of the scale will be taken. The captured images are then resolved through image processing toolbox. These resolved images are compared with standard scale. On the basis of comparison between test scale and standard scale calibration report is generated which is useful in instruments measurement field, also the uncertainties of measurement of the automated rotary system is analyzed.

Keywords – *Webcam, Uncertainty*

I. INTRODUCTION

In the Calibration field, there are number of ways for calibration of ruler scales e.g. photoelectric sensor for high resolution measurement, laser interferometer [2] etc. But all these methods are time consuming and costly. So, there is need of an automatic calibration system which provides more accuracy, cost effective and less time consuming.

Now-a-days, there is innovation in the field of Image Processing by using Matlab software. Matlab has many advanced computing capabilities and more features of resolution. Matlab has many applications which are very useful in all fields like education, image processing, signal generation and computing systems. Matlab can plays very important role in the accuracy of the calibrating devices in the calibration field by using image processing, which provides high resolution[9]. This is biggest advancement in the field of Calibration for accurate and effective analysis of the measurement by using ruler scales

Lacking of preciseness in automatic scale calibration isn't the good option for working in industries. Hence, research has been proposed for working on automated ruler scale calibration system using the rotary mechanism [1]. It uses a rotary bench with a webcam for calibration of ruler scale length<=15cm.This proposed system provides fast and automatic operation and economic solutions for calibration problems of ruler scales. The webcam is fitted on a rotary rod along the standardized test scale, with both linear and rotary motion of webcam gives the capability to take precise images of both the scales will be taken which is then resolved through image processing toolbox. System measures pitches of the scales which are used to compare them with the standard scale and the uncertainties of measurement of the automated rotary system are analyzed.

II. RELATED WORK

Suricha Kraiprawes et al. (2008) In this paper an automated calibration system is design with the use of an optical sensor [1]. In this project reflecting optical sensor was combined with a rotary bench to built an automatically calibration system for linear scales. An optical sensor was fitted on a rotary bench along with the liner scales; it was used for identifying the lines on a linear scale. When the light falls on the lines intensity is reflected and sensor detects this intensity and count as a marked lines. The amplifier was used for detection of reflected intensity and reference value was used for comparison of reflected light, also generate compared electric voltage and total length of linear scale was calculated by counting the number of a mark lines on the linear scale [3].

In an interval the distance between the marked lines was measured with a use of rotary bench system within a 1 second. Thus, in 1000 seconds with the help of this calibration system calibration of 1000 mm long linear scale will be completed. Therefore this method is cheaper and also operation of this system is fast, easy and automatic.

Gyula Hermann et al.(2011) This project is based on CCD camera. In this research work calibration of ruler scales a Zeiss length measuring machine was used and uses a few micrometers distance of pitch [3]. For capturing distances and the line sizes CCD camera with high resolution optics was attached and computer was also added. Backlighting and lens illumination was controlled with the help of an appropriate LED illumination system. The carriage system was used for providing linear positioning motion on which the scale rests. In this research paper various definitions of the pitch distance are described. For determining the pitch distance simple algorithms were derived with the help of these described definitions. In this project an important issues are elimination of the influences of contamination of the scale and to minimize the effect of diffraction and non-linearity, for improving measurement accuracy selection of an appropriate optics and illumination, therefore to overcome these issues. From the Figure 2.2 shown an ultrasonic piezomotor is used for carrying the scale carriage system and it provides the nanometer resolution. HP laser interferometer was used for measurement of displacement. For higher resolution near field microscope can be used in place of CCD camera.

Michael W. Cresswell et al.(2000) This research work describes the calibration of ruler scale with the help of electrical test structure metrology [3]**.** In industry various applications uses ruler scales for measurement**.** An optically instruments such as microscopes stage micrometer generally calibrated with the use of a small graduated glass scale. Optical calibration techniques are time consuming and costly therefore for critical applications stage micrometer are not calibrated therefore this paper presented a new method for calibrating of ruler scales which is based on test structure of electrical metrology [8].

The NIST Length Scale Interferometer (1999) This project is based on the He-Ne interferometer laser. Figure 2.5 shows elements of HP interferometer [4]. HP laser can be easily connected to the automated, digitally controlled system. HP system is much simpler for alignment of the optical components. Due to forward and backward movement of carriage system sinusoidal uncertainties are generated. Therefore axis of the interferometer is aligned to the graduation scale axis for minimizing the uncertainties of the measurement produced by carriage pitch from straightness deviations of yaw and waviness.1/4 wavelength is used for operation of HP laser interferometer in counting mode with interpolation between counts. For calibration of scales various environmental conditions are required i.e. air, pressure, humidity etc therefore in the interferometer path refractive index of air is calculated by the barometric pressure, relative humidity,co2 content and temperature of air . Refractive index is used to calculate length scale computations and vacuum wavelength calibrated by NIST for driving of ambient wavelength.

In this research paper interferometer measured the carriage displacement for Calibration of line scales and measured value corresponds exactly to scale interval lengths. When graduation in view carriage gets stopped and key correspondence to line centring action of photoelectric microscope. For line spacing on the ruler scale computer or controller is interfaced with stepping motor and its indexer to move the carriage distance corresponding to nominal length. When measured lines appears in the microscope field speed of stepping motor become slow down and actuates the microscope electronic system which generate a trigger signal to stop the motor and calibration reach in final indexing steps for every interval and carriage gets stopped and cut off the line centring electronic circuits. By means of electro hydraulic actuators graduation is in the centre of the field on the scale support structure. Thus calibration of ruler scale starting from zero graduation to the terminal graduation with a use of laser interferometer which noted the value from the centre line to the preselected centre line. This paper also describes that the averaging and statistical analysis needed several passes for obtaining redundancy.

Jenny Wirandi et al.(2006) Calibration of modern instruments faces so many calibration problems [7]. In this research paper number of problems are describes that occurs when apply to measurement uncertainty guide which produces uncertainty in measurement. Controlling and analyzing of modern instruments are difficult because these instruments are automatic, therefore evaluation of these instruments are complicated in each step of measurement. This paper also describes that the calibration of same dimension instruments is done by different-different technique therefore difficult to compare with other instruments which having same dimensions also many of these instruments are specific instrument parameters. Often, chance of tracing of these parameters in calibration is very low and may produce large uncertainty in the results. This paper also describes the effect of human aspect in the measurement and calibration process [5].

III. PROPOSED RESEARCH WORK

The proposed system comprises a rotary machine along with a webcam so that a machine may be designed that will calibrate the ruler scale automatically [1]. The mounting of webcam has been performed on the motion rod. With the help of webcam and rotary machine; snaps of both scales will be taken. These will be resolved with the help of image processing toolbox. The system will measure the lines and count the number of them. After this they must be compared with the help of standard sets.

This proposed system provides fast and automatic operation and economic solutions for calibration problems of ruler scales. The webcam is fitted on a rotary rod along the standardized test scale, with both linear and rotary motion of webcam gives the capability to take precise images of both the scales will be taken which is then resolved through image processing toolbox [9]. System measures pitches of the scales which are used to compare them with the standard scale and the uncertainties of measurement of the automated rotary system are analyzed.

The webcam is moveable on the rotary bench from left to right or vice versa with the help of stepper motor as shown in Figure 1.5.Camera moves in both the direction at a constant velocity for measuring the total length of ruler scale. Stepper motor having fix step angle therefore it provides the constant motion to webcam and uncertainty in result is minimized. Webcam is fixed on the 20 cm × 10 cm × 20 cm fiber plate. For controlling the movement line guide way is used and also webcam is sited on it. Ball screw (diameter 26 mm), 20 cm long thread and nuts are used. Core of motor is attached at one end of ball screw and also flexibility is achieved by using aluminium coupling.

With the help of coupling, the discontinuity in movement was minimized when the core of motor is not aligned with screw core. In this proposed system stepper motor is used. It rotates at a constant speed with 7.5 degree in 1 step in both forward and backward directions. Therefore movement of camera is same as well as the speed of motor.

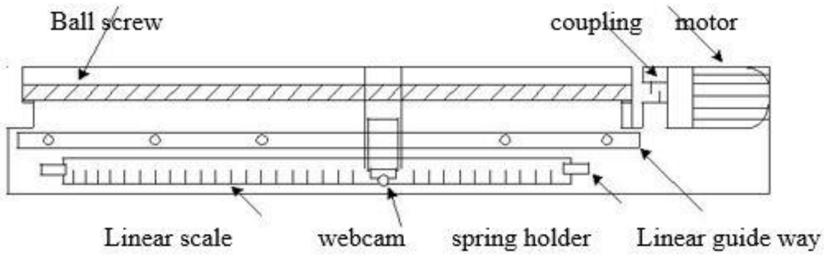

Fig.1: Model of Automated Calibration System for Ruler/Scale

IV. RESULTS

Figure 2 rotary bench system which is built is shown. There are two wooden plates, in between nylon rod is fixed. Camera is mounted on the rod and one side of rod is connected by stepper motor for rotary purpose.

Figure 3 shows the whole setup of automated calibration system for ruler scale. In which camera is physically connected to laptop by using usb cable and interfaced through image processing tool and captured images along the length of scale. Figure shows camera is fixed on the rotary bench and linearly move right to left direction through stepper motor.

Figure 4 shows the captured images of ruler/scale. These images are stored in the computer memory, on the basis of these images calibration report is generated which is shown below in the Table 1.

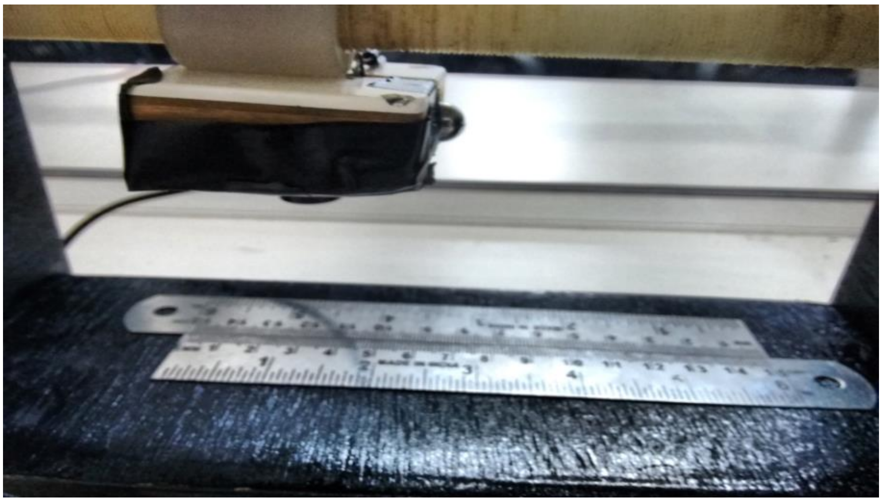

Fig.2: Rotary Bench System

Fig.3: Whole Setup

Fig.4: Captured Images

TABLE 1: CALIBRATION REPORT

Forward Direction			**Backward Direction**		
Scale1(cm)	**Scale2(cm)**	**Error (mm)**	**Scale1(cm)**	**Scale2(cm)**	**Error (mm)**
1.1	1	1	15	0	0
4	4.1	1	14.5	14.6	1
5	5.1	1	13	13.2	2
8.5	8.7	2	12	12.1	1
11	11.2	2	9	9.1	1
12	12.2	2	6	6.2	2
12.7	12.7	0	5.9	5.9	0
13	13.1	1	5	5.1	1
13.5	13.6	1	3	3.2	2
15	0	0	0.9	1	1

V. CONCLUSION AND DISCUSSION

There is lack of automated calibration systems for ruler scales. This thesis work eliminates difficulties of the calibration and provides fast and economic solution for instruments calibration. In this proposed system calibration is done by using rotary mechanism and camera therefore less no of uncertainties in the calibration report and level of accuracy is also increased. With the help of components like stepper motor, nylon rod, camera and image processing tool have made this thesis work fully automatic and uncertainty has been reduced significantly with no use of man power.

VI. REFERENCES

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