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A VISION SYSTEM FOR STANDARD PARTS INSPECTION AND MEASUREMENT *

Zhou Man-li , Li Bin , Zhu Yao-ting
Zhang Zao-qun Wang Xiao-yan Qian Si-cong

Dept. of Elec. & Info. Engr.
HUST , Wuhan , P.R.China

ABSTRACT

This paper presents a machine vision system for male screw defects inspection and measurement . The proposed automation inspection and measurement system consists of a parallel light , a set of optical components , an industrial TV camera , PCvision board , a microcomputer and color display . Image of the tested male screw is taken from TV camera and stored in frame memory in 512x512x8 bits form .

Image subtraction is used to detect defects of products . Parameter method is used to calculate geometric parameters of male screw , such as length of cylinder , height of shoulder , pitch , inside diameter of thread , outside diameter of thread , medium diameter of thread , and flank angle etc .

According to visual inspection and measurement results and prior knowledge , some pieces of advice are given to the operator for machine maintenance .

Finally , experiment results are given .

INTRODUCTION

The inspection of products is the key step in manufacturing which is still carried out largely by human operators . The disadvantages of human inspection are very obvious that the cost , speed and the fact that human are subject to fatigue , errors in judgment and variety in decision threshold .

'Recent years , machine vision inspection has become one of the hotest research topic , advances in machine vision and artificial intelligence software along with a continuously improving ratio of cost/performance in hardware made it possible to make up different machine vision systems for practical use in industry . Many valuable works have been done in different fields . [1,2,3,4]

This paper deals with inspection of standard male screw from Wuhan truck standard part factory . The proposed system not only implement products inspection but parameter measurement . Using these visual information , it's easy to realize production quality control and products quality analysis .

In order to reach high speed of inspection and measurement , it always desired that tested part has fixed position , orientation , and is lumined by a stable parallel light source . If tested part is very small , these conditions are not only desirable but also reasonable .

Measurement accuracy highly depends on the resolution of system , size of tested part , and software itself . System is designed in two kind of resolution , microscale is used for thread measurement , and mesoscale is for others .

SYSTEM CONSTITUTION AND IMAGE PREPROCESSING

The system consists of a parallel light source , a set of optical component , a TV camera , PCvision plus board , a microcomputer IBM/PC-AT and output device . The system hardware constitution is shown in Fig. 1 and software diagram is shown in Fig. 2 . Parallel light provides stable , uniform luminous intensity on the tested part . The tested part itself is clmaped by a clamping device , so that it shows a fixed position and orientation . These conditions greatly reduce the work of processing .

Optical amplifiers contribute two kind of amplification . Microscale is used for thread measurement , and mesoscale for others .

PCvision plus board provides a

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frame memory used to store image of tested part . Its constitution is shown in Fig. 3 .

Preprocessing : This module includes calibrating , image binary , geometric distortion correcting , object boundary tracing . Calibrating is trained to reference data as measuring standard . There are two kind of calibrating methods , one is to take in internal gauge picture into computer and calculate the parameter as reference data for later use and the other is to put in value of standard parameter into computer directly according to the calibration results .

PARAMETER MEASUREMENT

This is the main module of the system . It is divided into two parts -- microscale and mesoscale measure .

1. Microscale is used for thread measurement . It consists of three steps : preprocessing , determining the character point (P) and measuring control point (CP) and calculating the workpieces parameter (shown in Fig.4 (a) , (b) and (c)) . One of the most important step is second step because measurement accuracy is greatly subject to the accuracy of P and CP . There are three decision rules embodied in algorithm for determining P and CP precisely. Those are curvature thresholding , curve fitting and knowledge guiding . The curve fitting algorithm fits image contour piecewise and read just the position of break point according to its distance to the fitted line . Prior knowledge about tested part parameter is used to guide P and CP selecting , so that algorithm could avoid influence caused by noise . Other steps simulate the traditional optical project image measurement method usually used in laboratory . Parameter calculation is based on the parameter definition of male screw . The measuring parameter includes medium diameter , pitch of screw , flank angle etc .

2. Mesoscale is used for solid screw measurement . It consists of three steps : preprocessing , curve segmentation and parameter calculating (shown in Fig.5 (a) , (b) and (c)) . The most important step is the second step . If second step is error , the measuring step would be stopped . The measuring parameter includes outside diameter , inside diameter , medium diameter , the head width of corner to corner , the length of cylinder and the height of shoulder etc .

TEMPLATE MATCHING

Template matching here is actually image subtraction for comparing the image with reference template directly . Generally speaking , in order to match both image , a accurate clamping is needed . This is hardly used in our system due to the rotation of thread .

The proposed method extracts the steady geometric features of tested part at first . For example , medium axis , mass center , the mean of peak point position etc , and based on those features to generate the reference template , then compares the tested part image and reference template . If error of tested image within the accuracy requirement , it is accepted , otherwise , rejected .

This method allows tested part changing a bit in position and orientation on image plane . So it is more flexible and useful .

PRODUCTION MACHINE MAINTAINING

This is a visual-based machine maintenance and diagnosis module . The aim of this module is to help operators off line monitoring the production procedure .

In practice , operators continuouslly inspect sampling parts being produced using different gauges . According to inspecting results , operators maintain working machine and adjust components of each working position in a normal condition whenever it is out of work . This is not easy for an apprentice , because the relationship between inspecting results and adjusting action are rather complicated .

This module contains a small knowledge-base , it consists of a data base and several dozen experience rules . Data base stores tested and reference parts parameter value . System uses this data and knowledge , automaticaly reasons and gives a pieces of advice which is compatible with experience mechanist to operators .

EXPERIMENT RESULTS AND ANALYSIS

The system measuring results for male screw is shown in table 1 . The colume of table 1 presents the measurement parameter items and the raw shows the order of the tested part . Table 2 presents the manual measuring results for male screw .

Table 1 The system measuring results for male screw

Unit : (mm)

Parameter items / Part No.	P	F	D1	D2	D3	W	H
1	1.020	30 48'	5.244	4.575	5.882	11.350	4.140
2	1.016	30 48'	5.251	4.579	5.886	11.373	4.139
3	1.013	30 06'	5.335	4.590	5.849	11.344	4.143

Table 2 The manual measuring results for male screw

Unit : (mm)

Parameter items / Part No.	P	F	D1	D2	D3	W	H
1	1.000	29 03'	5.274	4.589	5.894	11.380	4.120
2	1.002	29 32'	5.272	4.552	5.889	11.380	4.120
3	1.007	29 28'	5.375	4.608	5.823	11.380	4.120

P : Pitch , F : Flank angle
D1 : medium diameter , D2 : internal diameter , D3 : external diameter .
W : the head width of corner to coener , H : the height of should .

Compare with table1 and table2 , it is easy to find : The system measuring results is general smaller than the manual measuring results except the flank angle and the height of should . It is obviously that the test part is parallel lumined by the source . If the test part griped by a clamping device is slightly inclined , the above results will occur . The correction of these is doing now .

CONCLUSIONS

Visual inspection and image measurement are very promising in different kind of industry parts , metal image and medical image analysis .

This system is suitable for planar and symmetric parts . 3-D and inside hole parts inspection and measurement need further research .

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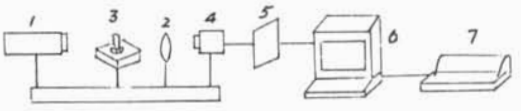


Fig. 1 Block diagram of vision system
1. light source 2. optical component 3. tested part and clamping device
4. TV camera 5. frame memory 6. microcomputer 7. output device

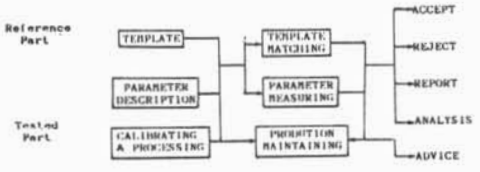


Fig. 2 Block diagram of software

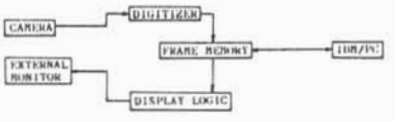
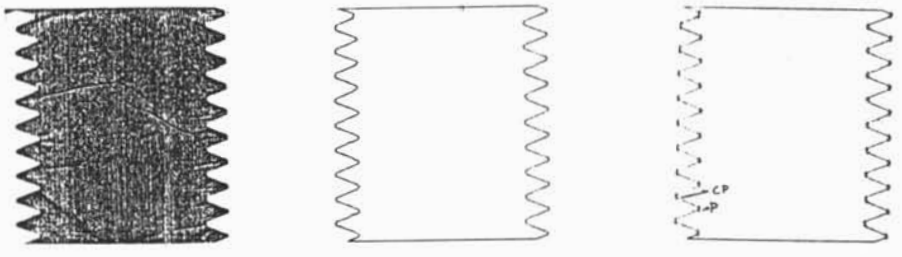
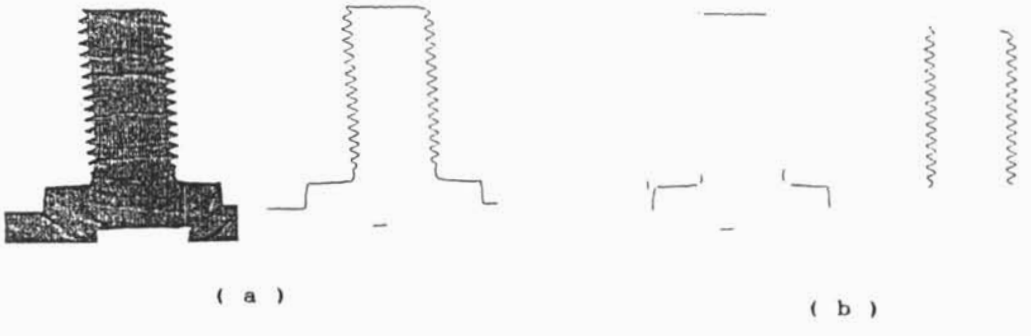


Fig. 3 components of a PCvision plus board



(a) (b) (c)

Fig. 4 thread measurement setp in microscale



(a) (b)

(c)

Fig. 5 solid measurement step in mesoscale