머신 비전을 이용한 카 시트 쿠션 프레임 검사 시스템 개발

조셀리토 [1*], 정호 [1], 장봉춘 [2]
[1] 안동대학교 대학원 기계공학과, [2*]안동대 기계공학과

Development of an Inspection System for Car Seat Bottom Cushion Frame Using Machine Vision

J. D. Tucit[1]*, H. Jung [1], B.C. Jang[2]
[1] Graduate Student, Dept. of Mech. Eng., Andong National Univ., [2] Professor, Dept. of Mech. Eng., Andong National University

Key words : machine vision, inspection system, MVIS, Vision Builder AI, multiple image acquisition, car seat frame

1. Introduction

The requirements of today's automotive industries are very much higher than it used to be. Processes that are formerly performed manually are being automated mainly because of the clamor for consistency and quality. Though it can be argued that manual inspection can be more effective than automated systems, especially when the attributes to be inspected are more qualitative than quantitative, there are high risks of inconsistencies in the inspection results.

This study deals with the improvements to a previously constructed Machine Vision Inspection System (MVIS) for a car seat bottom cushion frame. It uses machine vision techniques that can be an alternative for human inspectors.

The first prototype utilized a colored CCD camera attached to a PC through a frame grabber. It has overhead lighting and makes use of National Instrument's Vision Builder AI software Measure Intensity Method. It had been successful in verifying the presence or absence of holes, nuts, welding spots, and other parts as well. However, the first prototype also had some shortcomings. For instance, it can verify if a nut is present or not but it does not have the capability to check if the nut is aligned to the hole where it was welded unto. Another is that because of the camera's high working distance the image distortions are also high. Though this MVIS proved to be effective in the verification for parts presence, the industries' needs for a higher precision inspection system leaves a lot of room for improvement.

The information gathered from testing the previous MVIS led to the changes that can be found on the next prototype. This paper focused on testing the proposed improvements stimulated by the following objectives: (a) to improve the MVIS by using 4 cameras, instead of just one for image acquisition, (b) to test if the design improvements, based from the observations and recommendations obtained from the previous prototype, would at least be able to reach a level of precision acceptable to the industries, and (c) to develop an inspection algorithm that complements the improvements on the system and the needs of the application.

2. Product Description

The product used for the development is a standard car seat bottom cushion frame which weighs about 2.5 kilograms and measures approximately 500 x 500 x 100 mm. It is made from thin stainless and galvanized metal sheets that were cut, pressed and welded. Bored thru this particular sample are 17 holes, wherein nuts are welded on top of 8 of them. There are 3 springs fastened via a packing on each end. Then there is also the side and underneath brackets which are welded on the frame. Due to its curves, some holes that are supposed to be round appears to be elliptic and the holes where nuts are welded over are also not clearly seen if looked upon at the top.

3. Inspection Booth Development

The inspection booth (Figure 1) is basically a wooden closet which is 182 cm high, 86 cm wide and 72 cm thick, with the control panel located at the right side. The ceiling is composed of aluminum profiles bolted together to facilitate the easier attachments of the cameras with an added advantage of being less cumbersome when there are adjustments to be made regarding camera positions. The computer can be located someplace else with the cameras connected to it thru an IMAQ-A6822 and a frame grabber.

For higher precision visual inspections, the distortions must be minimized as much as possible. Using four XC-HR50 black-and-white video cameras, the working distance is lower because each camera will be capturing a quarter portion of the car seat resulting to minimal distortions. To improve the contrast, aside from the four fluorescent lamps on the inside walls of the inspection booth, a provision for backlighting was added.

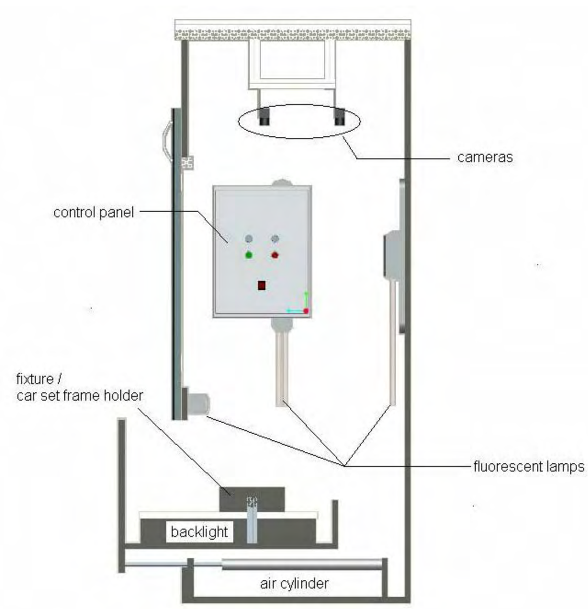

Fig. 1 The improved MVIS Inspection Booth

4. Inspection Algorithm Development

4.1 Vision Builder Script

In creating the Vision Builder scripts, careful consideration were taken in choosing the base templates. One factor considered is their uniqueness in the image captured and the other is whether the part would have the least chance of any damage or defect. This is to ensure that even if there would be certain misalignments when a product is fed in to the inspection booth or if there would be fluctuations in the light intensity, the template would still be found.

For the parts that need only presence verification, such as welding spots, nuts, springs and their packings, the Pattern Matching method was used. For the parts that need more than just presence verification, the Detect Object Step was used. This step was used not just for detecting the holes and determining if they are within the desired tolerances but also in detecting if the nuts are welded properly on top of the holes.

4.2 Algorithm Debugging and Testing

For the purpose of the car seat bottom cushion frame inspection, certain procedures were run to debug and test the Inspection Algorithm written with Vision Builder AI. These were all done to each of the four scripts.

The first test is the Good Quality Recognition Test (GQRT). It consists of acquiring an image of a good product then running the inspection. The inspection algorithm then is expected to return a decision of “VERIFIED” (Figure 2a).

The second test for the algorithm is the Missing Portion Recognition Test (MPRT). It is done by blocking one or more portions of the product expecting the inspection steps to recognize the missing portions by returning a “FAIL” decision (Figure 2b).

Fig. 2 MVIS Sample Test Results: (a) GQRT for lower right portion all returning “VERIFIED”, (b) MPRT sample for lower right portion of the car seat bottom cushion frame.

For the portions that need higher precision, such as checking for the alignment of nuts to the holes, a test similar to MPRT was done. The misalignment of a welded nut to a hole was simulated. The misalignment was such that it is just outside the accepted tolerance. The inspection step must then be able to return a decision of “FAIL”.

The tests for the algorithms were carried out repetitively to test their reliability. Once the algorithms are deemed reliable enough, the Workplace Simulation Test was carried out. For this, the PLC was programmed to open and then close within fifteen (15) seconds. This was established from the first prototype as the ideal time enough for the opening and closing of the feeding chamber, plus a delay which was deemed comfortable for the removal of the inspected frame and placement of the succeeding frame. The different defects that were anticipated to come up during actual inspection were simulated, and in each of these, the inspection algorithms were run and timed. For each of the algorithms, the average recorded time was 58.744 milliseconds or roughly 0.1 second. This places the time for running all four scripts at 0.4 seconds. Adding the time for the closing and opening of an inspection algorithm, which was approximated to be around 1 second for each, the total approximate time, are now around 20 seconds for each inspection or about 1440 pieces for an 8-hour work shift. Considering that the inspection time would be consistent whatever the time, as opposed to manual inspection that usually deteriorates at certain times of the day, the use of MVIS for car seat bottom cushion frame inspection was shown to be viable.

5. Conclusion

A more precise and accurate semi-automated machine vision inspection system for car seat bottom cushion frames was successfully developed. The use of four cameras in improving the MVIS, by lessening the image distortions, during real-time inspection of the car seat bottom cushion frame was established. The effectiveness of the algorithms developed from NI Vision Builder AI, were also shown to be effective and suitable for providing a more reliable and precise inspection.

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