# DEVELOPMENT OF A MACHINE VISION SYSTEM FOR AN AUTOMOBILE PLASTIC PART INSPECTION

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## ABSTRACT

Since human is vulnerable to emotional, physical and environmental distractions, most human inspectors cannot sustain a consistent 8-hour inspection in a day specifically for small components like door locking levers. As an alternative for human inspection, presented in this study is the development of a machine vision inspection system (MVIS) purposely for door locking levers. Comprises the development is the structure of the MVIS components, designed to meet the demands, features and specifications of door locking lever manufacturing companies in increasing their production throughput upon keeping the quality assured. This computer-based MVIS is designed to perform quality measures of detecting missing portions and defects like burr on every door locking lever. NI Vision Builder software for Automatic Inspection (AI) is found to be the optimum solution in configuring the needed quality measures. The proposed software has measurement techniques such as edge detecting and pattern-matching which are capable of gauging, detecting missing portion and checking alignment. Furthermore, this study exemplifies the incorporation of the optimized NI Builder inspection environment to the pre-inspection and post-inspection subsystems.

**Key Words**: Door Locking Lever, Machine Vision Inspection System (MVIS), Program Logic Controller (PLC), LabView Software, Virtual Instrument (VI), Image Acquisition, Mechatronics

## 1. INTRODUCTION

Consistency suffers in human inspection for many reasons like diverse concentration, time of day, length of shift and distractions from surroundings. Like human being, vision system could recognize different shapes or identify markings yet its vulnerability to physical and environmental distractions are limited and manageable. Thus, automobile parts like door locking lever could be sorted out consistently and automatically through vision system. Currently, vision system is working perfectly in many industrial applications like verifying barcodes and dates on food packaging, tracing soldering defects, robotic guidance and others. The introduction of machine vision inspection system (MVIS) into production industry to replace human inspection will certainly provide consistent quality assurance measurements to uphold good reputation from customers. In addition, this automation technology will provide labor cost savings.

Modern PC-based MVIS can inspect 20 to 25 parts per second depending on the number of operations required and the speed of the PC used. Thus, this high-speed inspection system will facilitate producers market the products of assured quality in a faster time. Fast order turnaround and lower production cost will lead to cheaper automobile parts and lower price of automobiles.

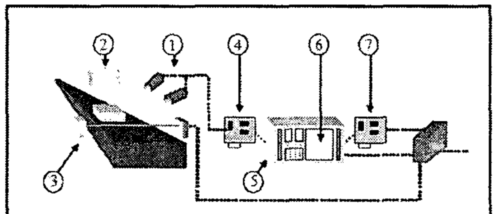


**Fig. 1** Typical Machine Vision Inspection System

A typical vision inspection set-up has seven vital components as depicted in Fig.1. Nowadays, several vision system products are offering powerful tools for product visual defect recognition. Moreover, the available vision system products in the market are robust enough to withstand the dust, heat and vibration present in a production environment. In this study, each component is optimized to come up with an effective, reliable and economical MVIS suited for the segregation of good quality locking levers from bad ones.

## 2. BACKGROUND

### 2.1 Product

The system is designed to inspect both the visual characteristics of the front and rear sides of the door locking lever shown in Fig. 2. A door locking lever is a hard plastic mold of irregular shape and surface designed for locking purpose in an automobile. In the figure, the edges marked with square highlights shall be ensured to be intact and free from burr during the inspection. While the surfaces that are marked with circle highlights shall be checked from burr existence. Also four portions shall be checked using gauging tool to make sure that the geometrics are correct. These inspection facts on door locking lever are based from the history of manual inspection of the product in which these portions are most frequently to be defective upon fabrication.

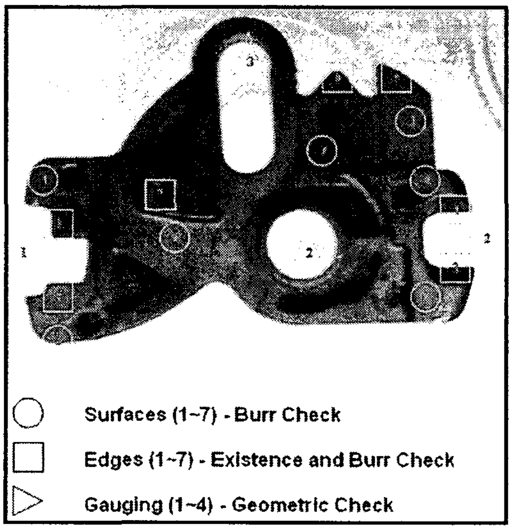


**Fig. 2** Portion Checking Scheme on the Product

### 2.2 Vision System

Accuracy and precision of the MVIS for automobile parts rely on the mechanical positioning and lighting. Hence, the camera can take a vivid picture of the part and process to extract the desired image information and compare with the image of good quality. The most important components of the machine vision system are the components involve in the optics and image path. Less expensive monochrome cameras are sufficient in this type of application since it can provide 90% of image visual data. However these cameras should be of high resolution to ensure the capture of the proper amount of visual information needed. Also, these should be of high quality and capable to withstand dirt, vibration and heat present in an automobile part manufacturing company. But even the best cameras will not perform well without good optics and adequate lighting. Both help in acquiring best image resolution. Lighting in this type of application usually are LEDs (Light Emitting Diode) of adjustable intensities. High frequency fluorescent, incandescent and quartz-halogen fiber optic are also potential to use. While best optics uses lenses that produce the best image resolution.

Another equally important component in a vision system is the frame grabber. It is used to acquire the image data from the camera and convert it to digital data. It also provides signals to control camera parameters like triggering, exposure/integration time and shutter speed. This is usually in the form of plug-in board installed in PC. Generally, inspection application requires faster PC that will give less time to process each image. Rugged PC is also required in vision system because of the dust, vibration and heat present in manufacturing environment.

Other components such as part sensor, inspection software and digital I/O and connections also play vital roles in a typical vision system. The part sensor sends a trigger signal when it senses the part in close proximity and/or in correct position. A vision system also needs inspection software which creates and executes programs, processes the image data and makes pass/fail decision. It is the brain of an inspection system. Hence, it is very important that the chosen software is capable of generating and debugging inspection programs, providing graphical user interface and giving environment needed to match the application requirements. Finally, when the inspection of the part is completed, the system must communicate with the outside system via digital I/O and network connection. This shall actuate the selection mechanism and segregate the good products from the bad ones.

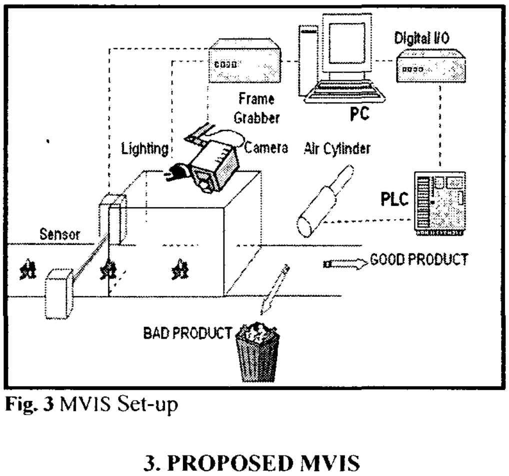


**Fig. 3** MVIS Set-up

## 3. PROPOSED MVIS

### 3.1 Component Optimization

Since 1985, optimistic growth of machine vision system is expanding in many applications. Many new vision suppliers are offering MVIS products of excellent features that cover many applications. Out of these many suppliers, each needed component in the desired inspection system is particularly investigated for optimization. Figure 3 depicts the set-up of the proposed vision system as solution to the inspection task. While Figure 4 denotes the proposed system as comprise by three subsystems. However, the PLC, feeder and selection mechanisms will not be discussed in detail.

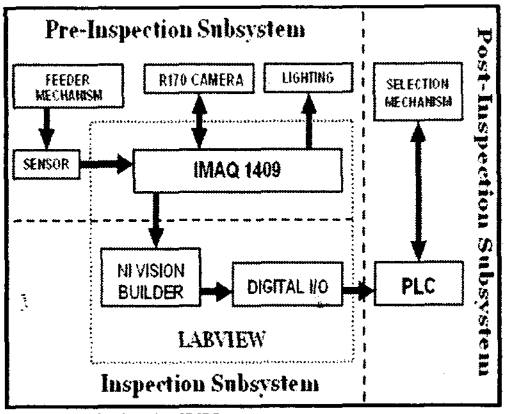


**Fig.4** Optimized MVIS

### 3.2 Pre-Inspection Subsystem

The pre-inspection subsystem is initiated by the feeder mechanism which is responsible for supplying door locking lever to the working field of view. The irregular shape and surface of the lever demand complex design of the part feeder. Figure 5 demonstrates the part feeder mechanism designed specifically for door locking lever. Since the objectives are to file the levers in line with the right side facing the camera and level them horizontally upon placing within the field of view regardless of the arbitrary positions. The proper placement of the product inside the working field of view determines the effectiveness of the system.

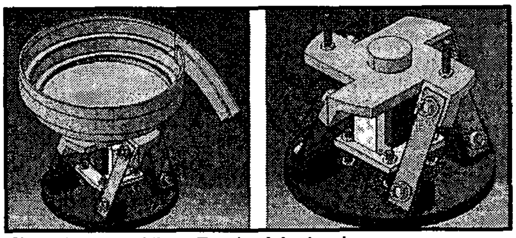

**Fig.5** Proposed Part Feeder Mechanism

So whenever the laser is blocked by the door locking lever upon feeding to the system, the optical sensor shall send signal to the Imag to actuate the lighting to provide illuminance. At the same time, it shall trigger shutter to control the mount of time the imaging surface is expose to light and then trigger the camera to take a snap of the part to be inspected. Once the image has been taken, Imaq grabs the image information from the camera and send it to the Vision Builder for the execution of the visual inspection process.

### 3.3 Inspection Subsystem

This phase of the proposed MVIS is the brain that makes the decisions. For the particular task, the chosen inspection software is able to process the image in real time even at arbitrary orientation. NI Vision Builder has inspection measurement techniques like edge detecting and pattern-matching. These techniques are capable of identifying the boundaries or edges of an object. The software analyzes the pixel values along the profile to detect significant intensity changes. Either of these techniques is capable of gauging, detecting missing portion and checking alignment. In this particular task, pattern-matching technique is utilized to gauge, check alignments and identify missing portions and burr. Situated in Fig. 6 is the flow chart of the inspection steps configured in NI Vision Builder software for one portion of the lever while Figure 7 denotes the application of these configured inspection steps into the image.

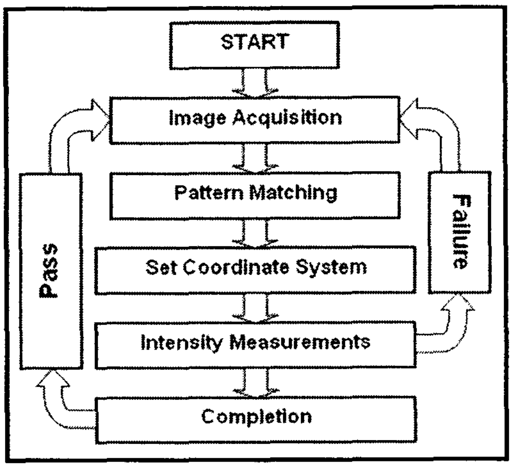


**Fig. 6** Flowchart of the Visual Inspection Steps

NI Vision Builder is scalable to powerful programming environment. It allows the designer to configure and benchmark a sequence of visual inspection steps and deploy the visual inspection system for automated inspection. Also, a designer can perform powerful visual inspection task and make decisions based on the results of individual tasks. NI Vision Builder (AI) is accessible to LabView that allows expansion of the capabilities of the inspection application. In image acquisition, an image of a good quality door locking lever is picked, simulated and set as template. Then, by using the match pattern step, the portions to be pattern matched are selected. The designer can pattern match every portion in the image he wants to inspect provided the pattern orientation must be set. Thus, the pattern matching tool can locate the reference point even if the image is rotated or scaled. For this particular task, several portions of the lever are needed to be pattern matched to inspect every lever fully and strictly (Fig. 2).

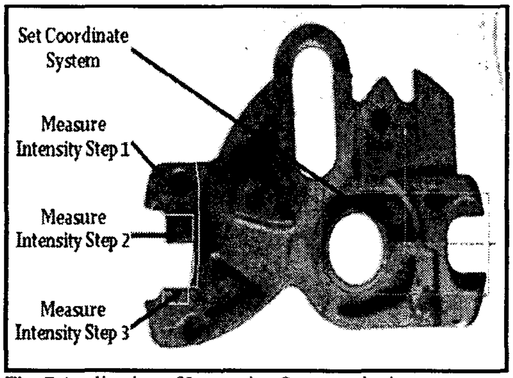


**Fig.** 7 Application of Inspection Steps on the image

### 3.4 Post-Inspection Subsystem

After the inspection process, the decision of the software shall be automatically conveyed to PLC to trigger the selection mechanism via digital I/O board. For this inspection task, the selection mechanism will consists of air cylinders provided in the conveyor. These air cylinders are actuated when a fail decision has been made. These shall push the lever out of the conveyor if the lever failed the inspection otherwise the lever shall continue on trailing for the next inspection process of the other side. The details on selection mechanism are not covered by this study.

Since the task is to inspect both sides (front and rear) of door locking lever, another MVIS is to be cascaded in the system. The conveyor is extended to another MVIS and another run of inspection shall be executed for the other side to finally sort the good quality door locking levers from the bad ones.

## 4. HUMAN INSPECTION SIMULATION

Machine vision can only accomplish what it has been programmed to do and not as versatile as human being in making decisions. For this particular task, the tolerance of humans in making quality decisions shall be simulated in the configured visual inspection steps to full extent. Threshold intensities are established from making several trials. Images of 200 pieces good quality door locking levers (manually checked) are ran into the configured inspection steps. In this trial, threshold intensities of every step that made failure decision are adjusted till it gives pass decision.

Another simulation experiment is done by mixing 7 images of bad quality door locking levers to the images of good quality ones. These are ran in the configured inspection steps and once more, threshold intensities are adjusted till the algorithm figure out the 7 bad quality door locking levers. The adjustments in the threshold intensities incorporates human factor to the configured sequence of inspection steps. Human factor reduces the tendency to commit false failures or wrongly identified good products as bad and other inspection errors to the utmost probability.

## 5. PILOT TESTING AND RESULTS

In the pilot testing of the proposed inspection software algorithm, a set of 200 pieces unchecked black locking levers are processed in succession. Based from the results, the proposed inspection software has been successful on recognizing shapes and identifying markings on the 200 door locking levers. Furthermore, the inspection steps algorithm has been able to identify correctly all the bad quality door locking levers among the 200 samples. There are also no false failures committed.

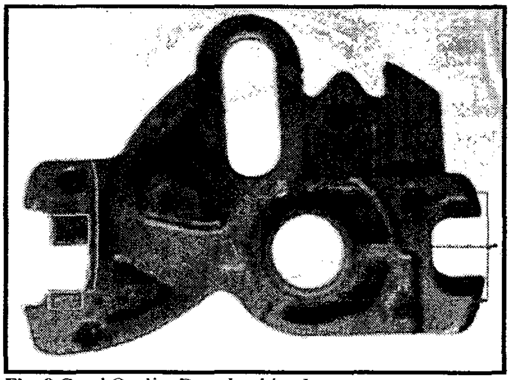

**Fig.** 8 Good Quality Door Locking Lever

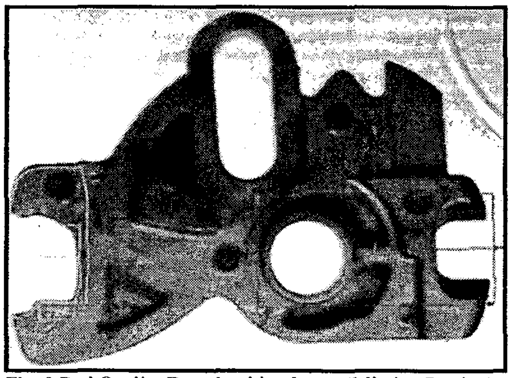

**Fig.** 9 Bad Quality Door Locking Lever (Missing Portion)

As declared by the inspection software, Fig. 8 is a good quality product after being processed. Illustrated in the figure, the edges are all intact and the surfaces are free from burr or any defect. As results of the testing, Figures 9, 10 and 11 are sample images of bad quality products. The image in Fig. 9 illustrates a missing portion on the upper edge while the image in Fig. 10 and 11 show missing portions on the lower edge.

## 6. INTEGRATION OF SUBSYSTEMS

Since the inspection algorithm is found to be efficient for the aimed application, incorporation of it with the rest of the subsystems is the next step. Each needed component for the proposed MVIS will not work as one system without interfacing software. LabView is very powerful software that acts as interpreter for the components to communicate with each other. The integration of the subsystems is done through the generation of Virtual Instrument (VI). As demonstrated in Fig. 4, the Imaq 1409, NI Vision Builder (inspection software) and digital I/O are integrated by LabView so their exchange of signals shall be done on virtual instrument (VI). Like in acquiring and displaying images with Imaq, the VI for this task, is available for continuous acquisitions and series of images. Acquiring an image and displaying it into your monitor can be done in many ways with LabView interface. Also by using trigger input (sensor) on Imaq device, VI shall be expanded to configure signal I/O for the sensor, lighting and camera.

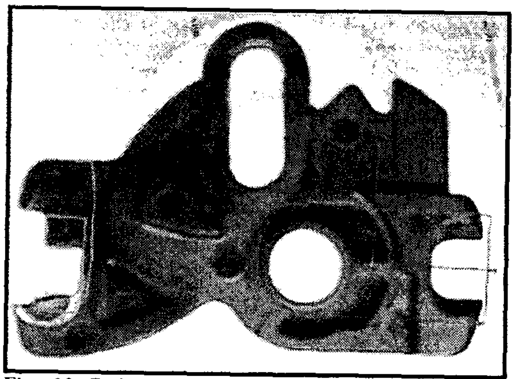

**Fig. 10** Bad Quality Door Locking Lever (Missing Portion)

**Fig. 11** Bad Quality Door Locking Lever (Missing Portion)

Upon grabbing the image data, Imaq shall feed the image data to the NI Builder via VI to perform the image-processing algorithm (Fig. 6). Also programmed in VI, the signals for rejection or acceptance from NI Builder shall be transmitted to PLC to actuate the air cylinders.

In wrapping up the study, the target output of the proposed system is 20~30 inspected frames per second. The time and sequencing of each subsystem핅 operation from sensor to PLC will be manipulated by the LabView VI. The proposed inspection system shall ease the human participation in switching on/off the system and putting door locking levers into the part feeder reservoir. Also, counter and repackaging can be incorporated in the system to minimize manpower and yield labor cost savings.

## 7. CONCLUSION

Machine vision is a high technology computer-based image processing system which permits automation of industrial inspection. The proposed MVIS for the door locking lever can viably replace human inspection and bestow many potential. These potentials include consistent quality outputs, fast and accurate inspection, production rate increase and labor cost savings.

The machine vision products involved in this study are few of the many machine vision products existing which offer equally excellent features for many applications. It is up to the designer to investigate and choose the optimum suitable for certain application. In this study, the software algorithm for one portion of the door locking lever is considered and successfully presented. The complete inspection algorithm of the full surface of the door locking lever as illustrated in Fig. 2 is imminent in the near future.

Furthermore, this study also aims to lead in other inspection applications in automobile industry especially for plastic products.


## ACKNOWLEDGEMENT

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