ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 4, April 2015

Automation for Instrument Cluster Panel Testing Using Machine Vision and NI-PXI Hardware-In-the-Loop

Dr.B.Sharmila[1], P.Venkadesan[2]

Professor, Dept. of EIE, Sri Ramakrishna Engineering College, Coimbatore, Tamilnadu, India[1]

PG Student, Dept. of CIE, Sri Ramakrishna Engineering College, Coimbatore, Tamilnadu, India[2]

ABSTRACT: This paper is proposed to develop automated instrument cluster panel testing and validation for shorten product development life cycle in automotive industry. The NI-PXI hardware-in-the- loop device combining with vision system is used for implementing closed loop automated Electronic Control Unit [ECU] testing. The LabVIEW NI-PXI system is simulating the real time hardwired and CAN signal for instrument cluster panel which is distributed by other ECUs in the vehicle network. The functionality result of concern test signal has been presented in the instrument cluster panel and the same signal has been captured by vision camera. The captured image is further processed by image processing algorithm for detecting the features such as detecting gauges, tell tale and text displays. Further, the closed loop result of each test case presents in the excel report for validation purpose using LabVIEW software. The test results were compared with ECU requirements specification for the purpose of flawless product delivery. The proposed system reduce the errors, time consumption and human intervention in ECU testing and validation.

KEYWORDS: ECU, Instrument cluster panel, Machine Vision, Hardware-in-the-loop.

I.INTRODUCTION

In recent year's automobile industry is one of fastest developing industries because number of persons using vehicle are increasing day by day. Automobiles these days are equipped with various electronic control units which provide the sophisticated vehicle driving information and improving engine efficiency. One of the vehicle driving information system is instrument cluster panel, in which comprises of various meter like speedometer, fuel gauge, LCD display and warning light indicators etc. The IC information assists the driver regarding safety related concern for driving the vehicle. With advancement of technologies, more information is available for the driver to assist him in better driving. Because of this, instrument cluster panel becomes complex embedded control system. Due to the increasing complexity of embedded systems and software in vehicles, the automotive industry faces an increasing need for testing and validation of hardware and software under real time environment for defect less product delivery before apply into real vehicle. At the same time product development life cycle must be shortened for vehicle manufacturers to be competitive on the global market, and an increased amount of testing and verification must be performed in less time. In earlier days, ECUs software and hardware functionalist are tested and validated manually. In the manual testing, it is difficult to cover all the test cases, time consumption, tedious and product development life cycle increased. The capturing results are not possible by manual testing because all the results are instantaneous and real time basis.

The manual testing difficulties are overcome by closed loop automated testing and validation scheme using [Hardware-In-the-Loop] system integrated with vision system. The past few years several HIL techniques have been implemented to automate instrument cluster panel testing and validation for flawless product delivery in the automotive industry. Yingping huang et al [1] presents a novel application integrating machine vision and HIL techniques for automated functional testing of a vehicle instrument cluster and *dspace HIL simulator* is used for rapid prototyping and model based testing approach. Amanjot dhaliwal et al [2] proposed HIL system for ECU unit tests and function tests on a single ECU using open-loop models and interaction between other ECUs can be simulated by generating CAN messages from the HIL system. T.L Narayana et a [3] implemented LabVIEW based HIL simulator for testing and

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 4, April 2015

validation of instrument cluster panel with integration of vision system for closed loop automation. Much work has been implemented to solve the problem of manual testing and validation of instrument cluster panel using machine vision and hardware-in-the-loop [4][5][6][7][8].

This paper presents NI-PXI based HIL techniques with integration of machine vision system for automated functional testing of a vehicle instrument cluster which is distributed among other ECUs available in the vehicle network.

In the system, NI-PXI HIL set up is used to generate the real time hardwired and CAN simulated signal to the instrument cluster panel with the help of LabVIEW interactive application software. The machine vision system with image algorithm to read data present in the instrument cluster panel like speed, fuel level, telltale and text message for fully automated closed loop test process. Also the LabVIEW application software generates automatic excel test result report for validation purpose. The closed loop automated system provides low errors, time saving, and repeatable test and reduce the manpower requirement.

This paper is organized as follows; Section II presents the HIL system architecture which is describing the hardware block structure of closed loop product testing environment. Section III elaborates implementation of HIL simulator and Section IV presents the implementation of machine vision system for detecting gauges. Finally, the paper ends with conclusion in section V.
.

II. HIL SYSTEM ARCHITECTURE

It is vision based hardware in the loop ECU testing. The Fig.1.is Show the system architecture with hardware in loop test equipment with vision system.

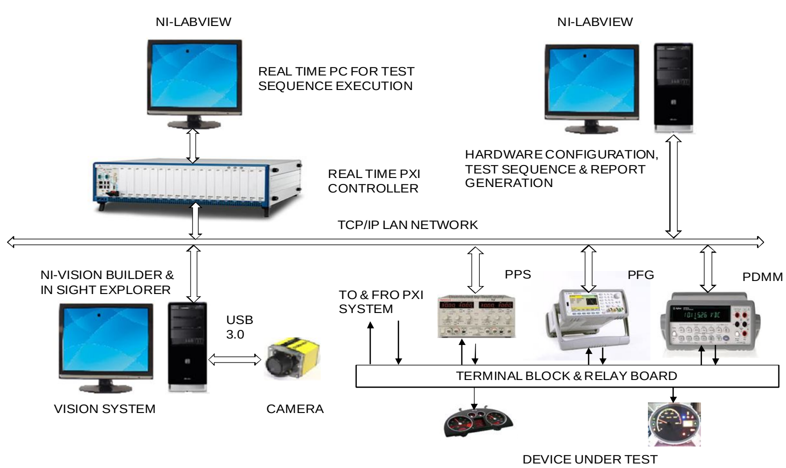

Fig. 1 Architecture of NI-PXI HIL system

It consists of five vital elements including machine vision system, NI-PXI HIL tester, NI-LabVIEW system, device under test and communication interfaces.

NI-PXI HIL tester: In the real time PXI system are composed of three basic components- chassis, system controller and peripheral modules. The chassis provides the rugged and modular packaging for the system. The chassis used here is 14-slot and 6U sizes. The ADLINK PXIe-3985 PXI express embedded controller, based on the fourth generation Intel Core i7 processor is specifically designed for hybrid PXI express-based real time testing systems. The PXI-6528 DIO card is used to simulate the ECU DIO functionality such as telltale and warning light indicator. The PXI-8513 CAN card is providing capability of simulating the CAN message signal which is distributed to other ECUs. The PXI-40-295 programmable resistor module is used to simulate the resistance based input functionality available in the ECU

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 4, April 2015

module. The Agilent-33500 Series is a 30 MHz synthesized waveform generator with built-in arbitrary waveform and pulse capabilities. It is combination of bench-top and system features makes this waveform generator a versatile solution for ECU testing requirements. The Sorensen power supply is providing variable power supply to ECU for simulating with different input voltage. The sleep mode current and operating current of ECU are measured directly using the agilent digital multi meter. All the PXI system peripheral and HIL equipment are interfaced with the help NI-LabVIEW software.

Device under Test: DUT or ECU is an instrument cluster panel of AMW tractor consists of following major components, speed, Fuel, pressure gauge, telltale, warning indicator and LCD display.

NI-LabVIEW System: The LabVIEW system is used to configure HIL test equipment, test case execution for functionality and report generation for each variant of cluster.

Machine Vision System: The vision system consists of Cognex camera and in-sight-explorer software tool. The in-sight-explorer has many vision tool libraries like blob and edge tool which is used for image processing algorithm implementation in closed loop ECU testing.

Communication Interfaces: The TCP/IP protocol is used for communication between NI LabVIEW and vision system. Also the peripheral instruments are communicated through TCP/IP protocol with LabVIEW system.

III. HIL SIMULATOR IMPLEMENTATION

In the HIL simulator, the peripheral modules and system controller are communicated through PCI/PCI Express bus which is available in PXI chassis. The HIL equipment such as programmable power supply and function generator is used for simulate the ECU functionality in Real time. NI-CAN card generates the CAN message for device under test which has been distributed to other ECUs in the CAN network. The DMM is used for measuring the sleep mode current passed through ECU. The machine vision system is integrated with NI-PXI system to achieve the closed loop observation for complete automated ECU testing. The PXI controller and HIL equipment are communicated through TCP/IP and USB protocol. The ECUs are interfaced through terminal block and relay board. The two types of NI-LABVIEW application tool has been developed for real time test sequence execution, hardware configuration and report generation for each variant of device under test. The image processing algorithm has been developed using in-sight-explorer software tool.

IV. MACHINE VISION SYSTEM IMPLEMENTATION

The machine vision system consists of a camera, lighting, optics and image processing software. A Cognex in-sight smart camera was selected for image acquisition and stand alone processing which offers a resolution of 800*600 and 64MB programmable flash memory for standalone operation. The acquisition rate of the smart camera is 102 fps. The image processing software [In-Sight-Explorer] provides a wide library vision tools for feature identification, verification, measurement and testing application. The primary source of illumination is from LED ring lights with directional front lighting, which provides high contrast between the object and background. The selection of optical lens depends on the field of view and working distance. The various functionalities of ECU result has been observed by vision system such as speed gauge, Fuel level, tell tale checking and text message read from ECU LCD. The closed loop automated machine vision system is shown in fig.2.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 4, April 2015

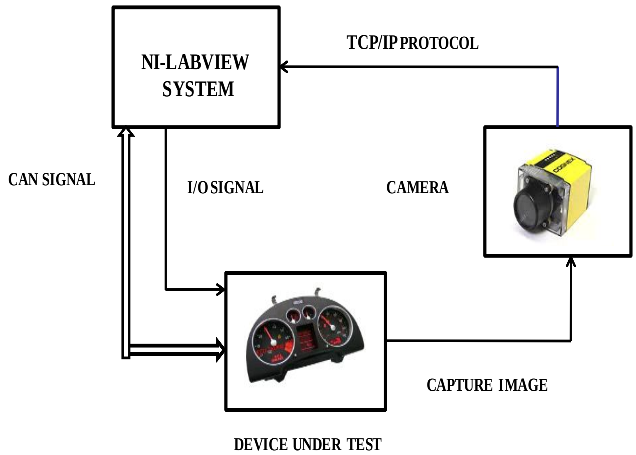

Fig. 2 Automated vision system

SPEED GAUGE DETECTION

The observation process for the speed as indicated by the needle of the speedometer is discussed in this section. When the message for the test is received by the ECU and image of ECU is taken by the USB Camera continuously. In captured image, two annular of region is drawn with the ends of the region coinciding with the extremes of the speedometer and then the blobs of the needle is detected using blob detection function which is available in the In-Sight Explorer as shown in fig.3.

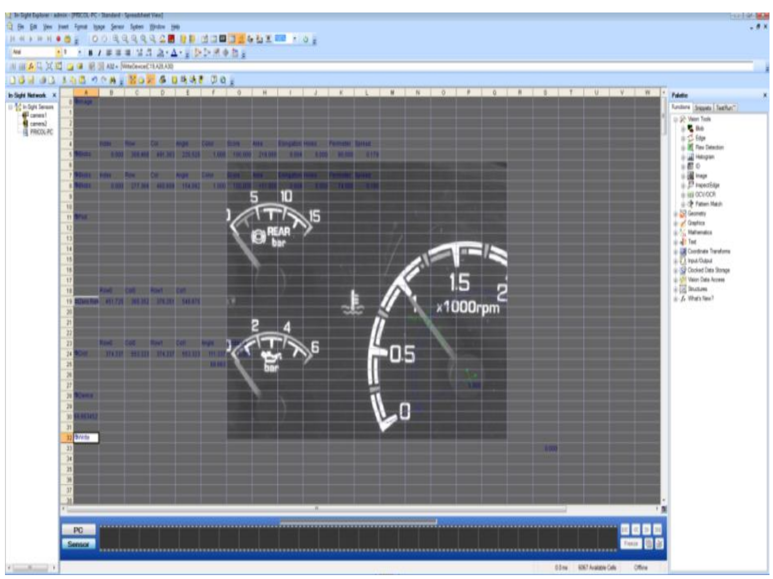

Fig. 3 Vision system implementation tool

Blob is a set of connected pixels with a gray scale value above or below a specified threshold. Once two blobs have been found in the ROI then draw line between two blobs. Also draw zero reference line between zero point and speed gauge pivot centre. These two lines are used to find the angle for corresponding speed. This angle helps to determine the original speed indicating in the meter. The speed gauge detection algorithm flowchart is shown in fig.4.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 4, April 2015

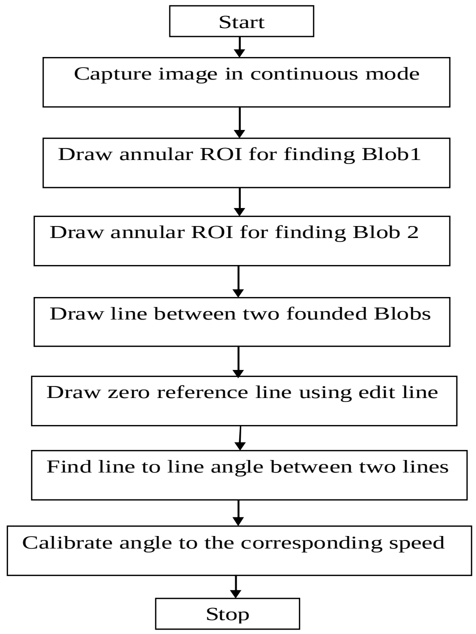

Fig. 4 Algorithm for speed gauge detection

FUEL LEVEL DETECTION

This test determines the fuel level status from the bar graph displayed in the fuel gauge. The "*Find multi Line*" edge tools are positioned to detect positions of 0%, 100% and actual fuel level. In machine vision terminology, an edge is defined as the boundary (a line, arc or circle) between two adjacent pixel groups with contrasting grayscale values.

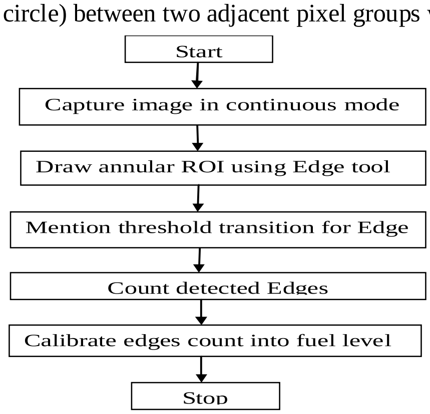

Fig. 5 Algorithm for fuel bar graph detection

The In-Sight Edge Tools are used to detect and process statistics about the found edges. Count the total edges detected by edge detection algorithm and calibrate the edge count into fuel level. The speed gauge detection algorithm flowchart is shown in fig.5.

TELL TALE DETECTION

There are various tell-tale indicators on the ECU such as power steering, seatbelt warning, low fuel indicator etc. These light up or glow depending upon the state of hardware of the vehicle. While the state of on or off can be detected using

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 4, April 2015

the algorithm to detect the difference between the telltale indicators, pattern matching is required. To run this test, a template of the indicator is loaded from the memory and learnt by the pattern max tool. The real-time input image of the cluster is then captured and loaded onto the In-Sight Explorer. The image is then scanned for the learnt pattern and an ROI is created around the pattern once it is detected. Initially, each standard symbol displayed in the cluster is trained using PatMaxTM tools and stored as master patterns. The image captured from the unit under test is compared with the trained patterns. The symbol is recognized based on the pattern matching score returned from the PatMaxTM tools.

TEXT MESSAGE DETECTION

The warning messages displayed in the message centre is in the need to be checked for their correctness. This test aims at recognizing and reporting these warning texts in the image processing library, OCR / OCV vision tools are designed to recognize a text string. However, this tool can only be used for identifying a text string with a known number of characters. In OCR/OCV, text fonts are trained before recognizing or verify the text. These trained fonts are stored in database with different instance. The ROI should be defined in the captured image area for recognizing and verification of text. The OCR/OCV is compared the ROI text with database fonts, once the text is match with database the found text has been sent to the API based on request.

V.CONCLUSION

Now a days, in automotive vehicle driving information system or instrument cluster panel has more functionality to assist the driver regarding safety concern. Because of this, instrument cluster panel becomes complex embedded control system. Testing these functionalities are required more test cases, but it is very tedious work to cover all the test cases by manually. The implemented NI-PXI system based automated product testing and validation which covered all the test cases in real time environment, therefore reduces the error and saves the time. The vision system read the instrument cluster panel result with good accuracy and real time manner. The NI-PXI system with integration of machine vision was proved efficiency of test and validation of automotive ECUs.

REFERENCES

[1] Yingping Huang and R. Peter Jones, "Design Validation Testing of Vehicle Instrument Cluster Using Machine Vision and Hardware-in-the-loop", in Proc.IEEE Conf on Vehicular Electronics and Safety, Sep 22-24, 2008.

[2] Amanjot Dhaliwal, Shreyas C. Nagaraj and Syed Ali " Hardware-In-The-Loop Simulation For Hybrid Electric Vehicles – An Overview, Lessons Learnt And Solutions Implemented", SAE International**,** 2009.

[3] T. L. Narayana, S.Venkat Rao and K.Gnasen, "Automated Instrument Cluster Testing Using Image Processing" American Journal of Intelligent Systems, Vol.3 (1) , pp.28-32, 2013.

[4] Thiago Martins and Alexander Wagner, "A Vision System for Electronic Control Unit Testing Using Hardware In the Loop", 2011.

[5] Sebastian Osswald, Pratik Sheth, Manfred Tscheligi "Hardware-in-the-Loop-Based Evaluation Platform for Automotive Instrument Cluster Development" EICS'13, June 24–27, 2013.

[6] A. Mouzakitis, D. Copp and R. Parker. "A hardware-in-the-loop system for testing automotive controller diagnostic software". Proceedings of the Sixteenth International Conference on Systems Engineering, (ICSE2003), Coventry, UK, vol. 2, pp. 589-594, 2003.

[7] I. R. Kendall and R. P. Jones, "An investigation into the use of hardware-in-the-loop simulation testing for automotive electronic control systems", Control Engineering Practice, vol. 7, pp. 1343-1356, 1999.

[8] A. Shafi, "Machine Vision in Automotive Manufacturing", Sensor Review, vol. 24, no. 4, pp. 337-342, 2004.

[9] Lab VIEW CORE 1 Course Manual- October 2009 Edition- Part Number 325290A-01.

[10] Lab VIEW CORE 2 Course Manual- October 2009 Edition- Part Number 325290A-01.