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A unified framework for automated inspection of handheld safety critical devices in production assemblies

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HIGHLIGHTS

- The framework provides system and process level integration of inspection lifecycle.
- Proposed for end-to-end automated production inspection of future handheld devices.
- Designed for automated inspection of hardware, software & mechanical characteristics.
- The proposed framework is tested for handheld safety critical devices.
- Fulfil the need of rigorous verification and validation prior to a field deployment.
- Handed Devices has become critical and can endanger life of human(s).
- These can also lead to substantial economic/environmental damage.

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ABSTRACT

Due to portability and ease of usage, handheld devices are widely used in various safety critical industrial applications. A failure in such devices either can endanger life of human(s) or can lead to substantial economic/environmental damage. Therefore, production inspection of handheld safety critical devices requires rigorous verification and validation prior to a field deployment to gain certain level of assurance. The research is aimed at devising a unified inspection framework for automated inspection of hardware, software and mechanical characteristics of handheld safety critical devices in production assemblies for smooth integration of all the required tools and technologies. The framework provides system and process level integration of all the stages of the inspection lifecycle for an end-to-end automated production inspection system. The testbeds are geared towards for reusability, flexibility and configurability of all the resources across various inspection stages. AVI (Automated Visual Inspection) system which exhibit specific characteristics is a core component of the proposed framework. The specific characteristics of the AVI system, a generalized architecture of the handheld safety critical devices for which the proposed framework is applicable. Also an integrated production inspection lifecycle for production assemblies of handheld safety critical devices is presented in this research paper.

1. Introduction

In safety critical systems a failure either can endanger the life of human(s) or can lead to substantial economic/environmental damage [1]. Therefore, development and production of safety critical devices requires rigorous verification and validation mechanisms that can fulfil all the safety measures prior to a field deployment. Due to the portability and ease of usage handheld safety critical devices are widely used in various industries like Aerospace Manufacturing, Material Handling, Amusement Ride Safety Stop, Automotive Manufacturing, Explosive/Flammable Environments Control, Mobile Crane Control, Conveyor Safety Stop, Mining, Medical and Gas Detectors for single/multi-gas detection in Mining, Space, Wells, Oil and Gas fields. Handheld safety critical devices have one or several electronic boards which are enclosed in a suitable mechanical assembly along with specific sensors and actuators. Handheld safety critical devices have one or several electronic boards which are enclosed in a suitable mechanical assembly along with specific sensors and actuators. A generalized architecture of a

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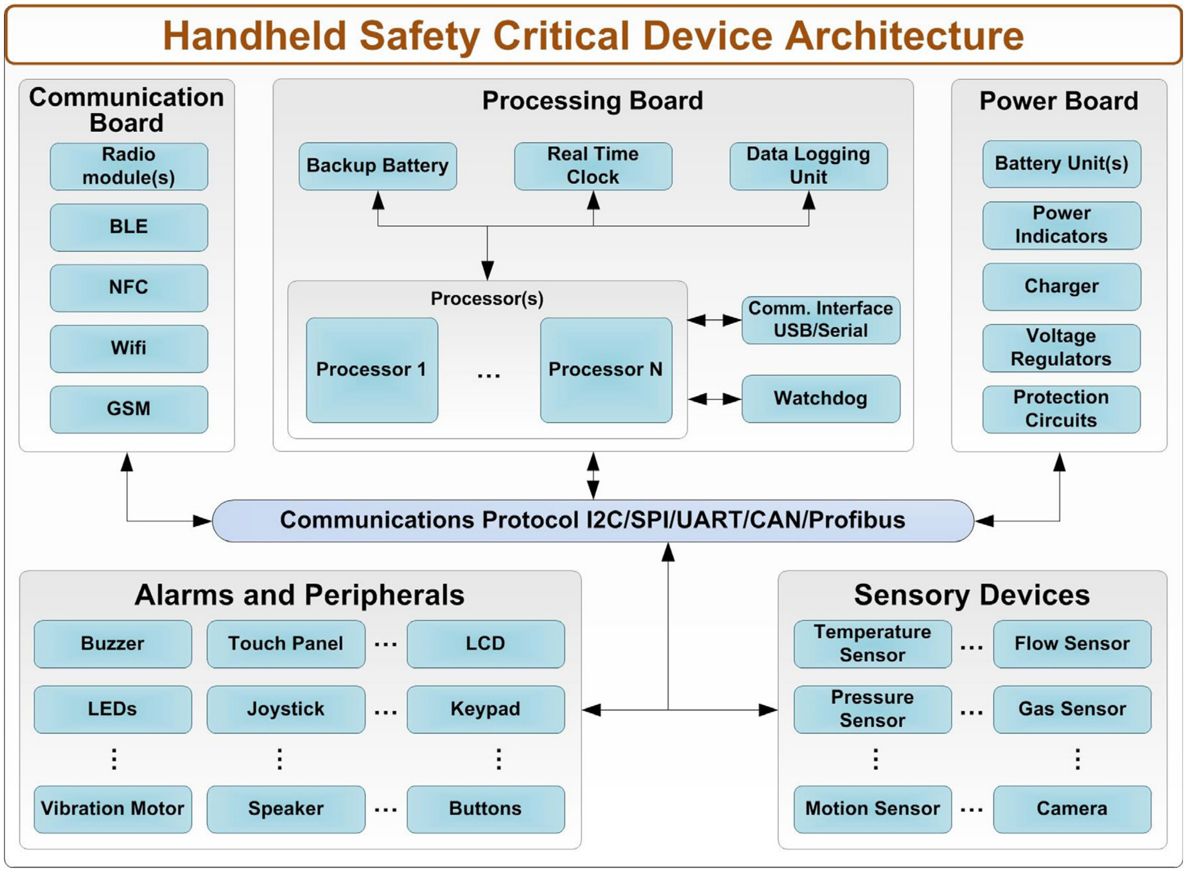

Fig. 1. Safety Critical Device Architecture.

handheld safety critical device on which the proposed framework can work is given in Fig. 1:

Processing board contains processors, memory, RTC, backup battery, ADC, DAC, etc. Processing board is the main command & control unit for all the critical operations of the device. The I/O board can have LEDs, LCD, buzzer, buttons, relays, etc. The I/O board provides main human interface along with actuating output interfaces and alarms. Sensor boards can have temperature sensor, pressure sensor, gas sensor, flow sensor etc. thus provide sensing capabilities to the device which is required to capture all the specific stimuli from the environment. Power board may have battery, status LEDs and charging circuitry, etc. All these boards can communicate/coordinate with each other using 12C, SPI, UART, Digital I/O, Analog I/O etc. Some of the boards can also be merged into a single board depending upon some design constraints.

The manufacturing process of these devices become very complex when they have to conform to a safety integrity level. Inspection mechanisms are devised to validate the functionality of such devices against its requirements specifications including standard compliance during the production assembly lifecycle. The two major types of inspection mechanisms are in-line/real-time inspection and post-process inspection. Traditionally human experts perform the inspection related measurements using conventional instruments [2].

The modern production assembly for electronic devices usually starts with building of the PCBs for a product after sourcing all the required components. The safety critical components sourced from other manufacturers are assembled based on certificates of conformity form respective supplier, however there is always a question on their test regime [3]. Once the PCB is done then all the electrical components are placed on the PCBs by automated machines. After the component placement inspection tests like solder paste inspection, bed of nail test, powered analog test, powered digital test, shorts test or any other test of similar nature can be performed by automated/semi-automated testing equipment. Then all other non-electrical/mechanical components are placed along with the components that cannot be placed by the automated machines. After that all necessary software/firmware installations and configurations are performed. Once the product is built then it is tested in real environment or close to real environment using a real time simulator [4].

The remainder of the research paper is organized as follow: Section 2 provides the related work. In Section 3 an integrated inspection lifecycle and interaction between different stages of the lifecycle are presented. Section 4 encapsulates the characteristics of the AVI system which are required for the automated inspection of handheld safety critical devices. Section 5 describes the state of the art unified inspection framework and Section 6 provides the industrial implementation of the proposed framework in the form of a case study to elaborate the results. Finally, in Section 7 our results and directions for the future enhancement are presented.

2. Related work

Specialized inspection methods are normally used during production inspection, for example computer aided inspection procedures are used to inspect injection molded electro-mechanical parts [5], LDV (Laser Doppler Vibrometry) is used in mechanical fault detection in production lines [6], high-precision X-ray and neutron imaging is used to accurate measurements of a variety of parts and its geometry [7], Magnetographic flaw detector is used for magnetographic inspection of ferromagnetic objects [8], ultrasonic inspection and cryo-ultrasonic testing for finding pores and crack-like defects over a wide range of materials [9,10], Sound