



IEEE Standard for General Requirements of Online Detection Based on Machine Vision in Intelligent Manufacturing

IEEE Computer Society

Developed by the
Smart Manufacturing Standards Committee

IEEE Std 2671™-2022

STANDARDS

IEEE Standard for General Requirements of Online Detection Based on Machine Vision in Intelligent Manufacturing

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Smart Manufacturing Standards Committee
of the
IEEE Computer Society

Approved 16 June 2022

IEEE SA Standards Board

Abstract: General requirements of online detection based on machine vision, including requirements for data format, data transmission processes, definition of application scenarios and performance metrics for evaluating the effect of online detection deployment are specified in this standard.

Keywords: general requirements, IEEE 2671™, machine vision, online detection

The Institute of Electrical and Electronics Engineers, Inc.
3 Park Avenue, New York, NY 10016-5997, USA

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PDF: ISBN 978-1-5044-8862-4 STD25529
Print: ISBN 978-1-5044-8863-1 STDPD25529

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The Working Group gratefully acknowledges the contributions of the following participants. Without their assistance and dedication, this standard would not have been completed.

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Introduction

This introduction is not part of IEEE Std 2671-2022, IEEE Standard for General Requirements of Online Detection Based on Machine Vision in Intelligent Manufacturing.

This standard provides requirements of data format, data quality, descriptive application scenarios and performance metrics to enable improved production processes through novel online defect detection on machine vision technologies, also it will improve the effectiveness of machine vision development.

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IEEE Standard for General Requirements of Online Detection Based on Machine Vision in Intelligent Manufacturing

1. Overview

1.1 Scope

This standard specifies through the general requirements of online detection based on machine vision, including requirements for data format, data transmission processes, definition of application scenarios and performance metrics for evaluating the effect of online detection deployment.

1.2 Purpose

The purpose of this standard is to provide requirements of data format, data quality, descriptive application scenarios and performance metrics to enable improved production processes through novel online defect detection on machine vision technologies, also it will improve the effectiveness of machine vision development.

1.3 Word usage

The word *shall* indicates mandatory requirements strictly to be followed in order to conform to the standard and from which no deviation is permitted (*shall equals is required to*).^{6,7}

The word *should* indicates that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required (*should equals is recommended that*).

The word *may* is used to indicate a course of action permissible within the limits of the standard (*may equals is permitted to*).

The word *can* is used for statements of possibility and capability, whether material, physical, or causal (*can equals is able to*).

⁶The use of the word *must* is deprecated and cannot be used when stating mandatory requirements; *must* is used only to describe unavoidable situations.

⁷The use of *will* is deprecated and cannot be used when stating mandatory requirements; *will* is only used in statements of fact.

2. Normative references

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used, so each referenced document is cited in text and its relationship to this document is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

IEC 62541-8:2015, OPC Unified Architecture – Part 8: Data Access.⁸

IEC TR 62390:2005, Common automation device – Profile guidelines.

3. Definitions, acronyms, and abbreviations

3.1 Definitions

For the purposes of this document, the following terms and definitions apply. The *IEEE Standards Dictionary Online* should be consulted for terms not defined in this clause.⁹

machine vision online detection system (MVOD): Comprehensive use of modern computers, image processing, pattern recognition, artificial intelligence, signal processing, optical-mechanical integration, Internet of things, big data, cloud computing and other technologies to imitate bio-visual functions, in the manufacturing process of intelligent manufacturing, the use of machines instead of the human eyes, it artificially uses various computer systems for detection, monitoring and control.

online: The detection system is integrated on the production line, using the soft sensing technology in real time detection and real-time feedback. On the premise of not affecting the production efficiency, the consistency and processing precision of the product are improved.

3.2 Acronyms and abbreviations

CRM	customer relationship management
DCP	data collection platform
DCS	distributed control system
DMS	deviation management system
ERP	enterprise resource planning
HMI	human-machine interface
IC	integrated circuit
MES	manufacturing execution system
MOM	manufacturing operation management
MVOD	machine vision online detection system
PCI	peripheral component interconnect
PLC	programmable logic controller
RAID	redundant arrays of independent disks

⁸IEC publications are available from the International Electrotechnical Commission (<https://www.iec.ch>) and the American National Standards Institute (<https://www.ansi.org/>).

⁹*IEEE Standards Dictionary Online* is available at: <https://dictionary.ieee.org>. An IEEE Account is required for access to the dictionary, and one can be created at no charge on the dictionary sign-in page.

RTSI real-time system integration
SPC statistical process control

4. Generic flows and architecture

4.1 Generic flows and generic architecture

Generic flows and architecture are illustrated in Figure 1.

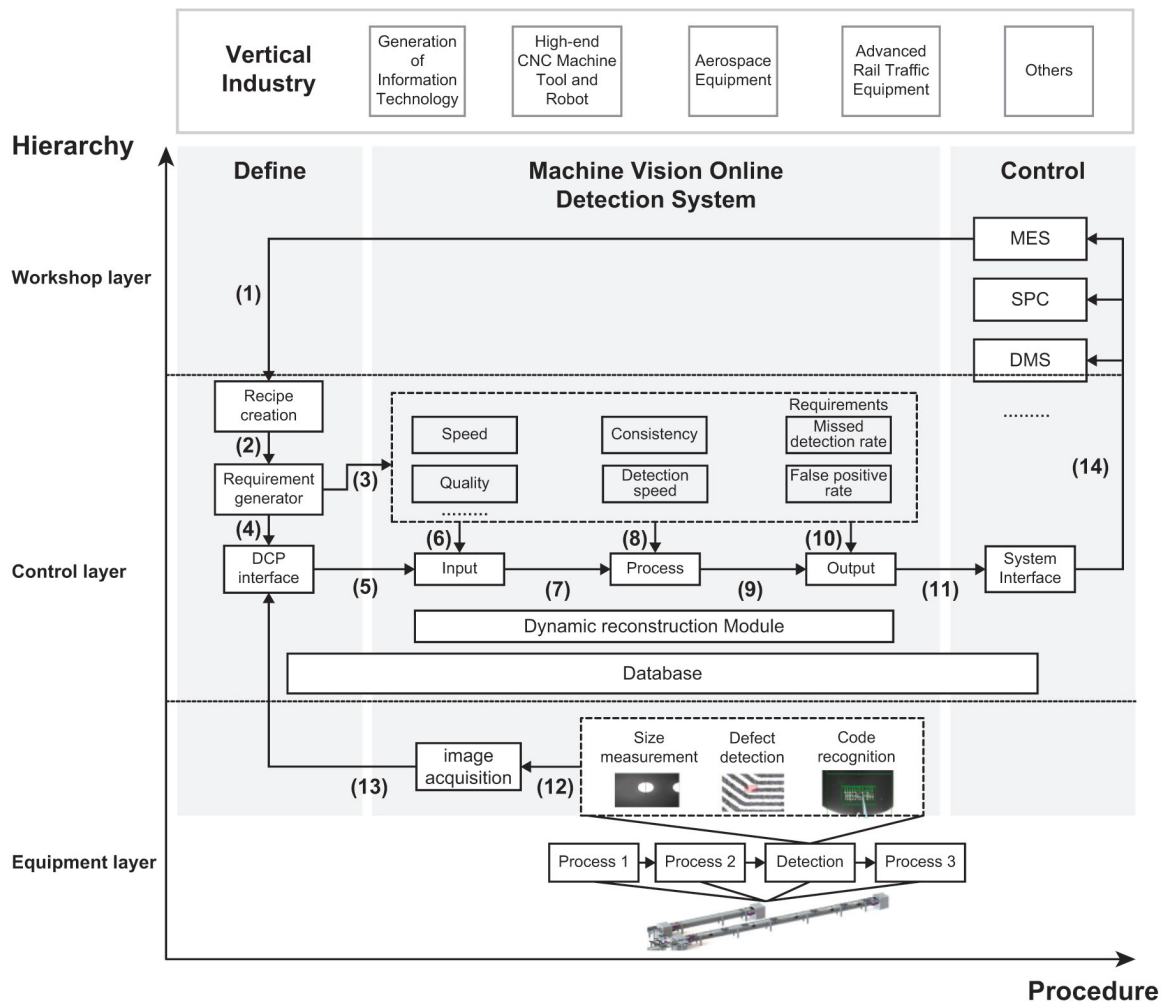


Figure 1—Generic flow and architecture

The machine vision online detection system (MVOD) complies with different automated detection requirements in different scenarios of various manufacturing industries, such as the new generation of information technology, high-end CNC machine tool and robot, aerospace equipment, advanced rail transportation equipment, and others.

In accordance with different production and test requirements, the operation manager shall define the testing recipe for the targeted product and deploy the same to the requirement generator, which will later set up the execution standard/specifications (speed, quality, etc.) for the “input, processing, and output” procedure.

From a hierarchy perspective, MVOD is involved over three layers including the equipment layer, control layer, and workshop layer.

Equipment layer: MVOD in this layer involves intelligent devices carrying out activities regarding vision, flow, etc.

Control layer: MVOD in this layer involves control systems that command the devices, such as programmable logic controller (PLC), distributed control system (DCS), and drives.

Workshop layer: MVOD in this layer involves interconnecting and interoperation with manufacturing operation management (MOM) systems such as manufacturing execution system (MES), statistical process control (SPC), and deviation management system (DMS).

A typical machine vision system comprises an image acquisition device set (light source, camera, lens), an image processing unit or image capturing card, image processing software, monitor, and communication or input/output unit. The typical system can be further broken down into host computer, video capturing card and video processor, video camera, CCTV lens, close-up lens, lighting device, light source, video display, control system, PLC device, PC-based controller, precision stage, and servo motion bench.

In the advanced manufacturing environment, it is expected to detect any defect as soon as it occurs. However, since most traditional processes could not have self-detection capability, monitor and control of visual quality depended on the afterword inspection process. To support the online machine inspection, normally the overall machine vision process time shall be no longer than the time interval between taking two pictures, including picture process, defect analysis, and data output, and typically shall be shorter than the time for the camera to take the picture.

From the procedure perspective, the whole process involves define, input, process, output, and control.

Define: The general operation request is typically generated from MES as sequence (1), as shown in [Figure 1](#), the recipe is created as sequence (2) and detail operation will be converted from recipe and requirements collected in the data collection platform (DCP) into the MVOD system (4). The acquired image as sequence (12) and (13) shall be collected into DCP as an original source to the MVOD system as sequence (5).

MVOD system: The input of MVOD shall acquire images according to the instructions and parameters from DCP (5) and detail operations (6). Then the process module converts objects inspected into image signals (7), which are further converted into digital signals by a specific image processing procedure depending on the pixel distribution, brightness, length, and other information (8). The output information shall include the results of image processing (9) of MVOD, which would be transferred to the system interface (11) in special forms specified by requirements (10).

Database: To store and retrieve data during MVOD operation and to support future analysis.

Dynamic reconstruction module: To provide a dynamic auto adjustable reconfiguration.

Control: To realize the interaction between the MVOD and MOM systems, i.e., MES, SPC, and DMS; to achieve and improve the analysis and control of manufacturing execution, product quality, and equipment efficiency; and to pass on the output data through the system interface as sequence (11), which will process the data according to the information requirements in the workshop layer as sequence (14).

The image acquisition and processing process of MVOD is on the edge side, while the cloud platform is mainly used for data storage and statistical analysis of MVOD. Data information such as images and detection results output by MVOD can be stored on the cloud platform, and the large-scale storage of cloud technology can help ensure the security of data. The stored data can be used for product quality traceability and product

quality trend statistical analysis. At the same time, it can also test and train the visual detection algorithm with the help of the computing ability of the cloud platform, so that the algorithm can be updated.

Some examples based on the architecture can be found in [Annex A](#) through [Annex E](#).

4.2 Scenario and defect modes

The machine vision inspection technology aims at detecting product defects, blurs, crumbles, and dented sections, etc. According to the machine vision image processing technology, the machine vision inspection equipment can realize the automatic inspection of particular product visual performance in the production process, so as to effectively screen out the damaged products, avoid the outflow of nonconformance items, improve product quality, and enhance company competitiveness.

4.2.1 Scenario (inspection type)

The scenarios include but are not limited to the following:

- Size measurement: size inspection of components and products
- Surface inspection: surface inspection of product outer appearance
- Inner inspection: inner constructions and layout
- Presence inspection: presence/absence inspection of component assembly completion
- Position inspection: position inspection of assembly size and angle

4.2.2 Defect modes (input acquisition characteristic)

The defect modes include but are not limited to the following:

- Size defect: deviation of actual size from designed requirements, distortion, and deformation, etc.
- Appearance defect: cracks, scratches, damages, dirty spots, color disparity, impurities, etc.
- Inner construction or layout nonconformance.
- Assembly error: installation omission, installation with wrong type, etc.
- Positioning defect: the installation precision does not meet the relevant standard/specification, or the installation position is wrong.
- Content error: image or picture is wrong, or the content does not match.
- Information error: errors of components information and product types.

5. Input

5.1 Requirements for image acquisition

Input acquires images according to the instructions and parameters from DCP.

Requirements for input are illustrated in [Figure 2](#).