INTERNATIONAL STANDARD

ISO/IEC 18038

First edition
2020-04

Information technology — Computer graphics, image processing and environmental representation — Sensor representation in mixed and augmented reality

Reference number
ISO/IEC 18038:2020(E)

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

Page

Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO and IEC shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents) or the IEC list of patent declarations received (see http://patents.iec.ch).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT)

This document was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 24, *Computer graphics, image processing and environmental data representation*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

This document defines a representation model for physical sensors to be included in a 3D mixed-reality world. It defines 3D modelling, rendering, simulation, and interfaces for physical sensors. It defines a set of principles, concepts, and functionalities for physical sensors applicable to the complete range of 3D mixed reality standards. It includes the following content:

— terms and definition for sensor interfaces;

— requirements and scope;

— a representation model of physical sensors that can be included in a 3D scene;

— 3D modelling, rendering, and simulation of physical sensors in a 3D scene;

— representation of the attributes of physical sensors in a 3D scene;

— representation of I/O data streaming of physical sensors in a 3D scene;

— representation of the interfaces for controlling physical sensors in a 3D scene;

— functionalities and base components;

— relevant physical sensor properties;

— interfaces with virtual and real worlds;

— use cases.

The objectives of this document are as follows:

— provide a reference model for physical sensor-based 3D mixed-reality applications;

— manage and control physical sensors with their physical properties in 3D mixed reality environments;

— provide an exchangeable information model necessary for transferring and storing data between sensor-based mixed-reality applications;

— support user interfaces with 3D mixed-reality worlds;

— support physical sensor interfaces with 3D mixed-reality worlds.

Information technology — Computer graphics, image processing and environmental representation — Sensor representation in mixed and augmented reality

1 Scope

This document defines the framework and information reference model for representing sensor-based 3D mixed-reality worlds. It defines concepts, an information model, architecture, system functions, and how to integrate 3D virtual worlds and physical sensors in order to provide mixed-reality applications with physical sensor interfaces. It defines an exchange format necessary for transferring and storing data between physical sensor-based mixed-reality applications.

This document specifies the following functionalities:

a) representation of physical sensors in a 3D scene;

b) definition of physical sensors in a 3D scene;

c) representation of functionalities of each physical sensor in a 3D scene;

d) representation of physical properties of each physical sensor in a 3D scene;

e) management of physical sensors in a 3D scene;

f) interface with physical sensor information in a 3D scene.

This document defines a reference model for physical sensor-based mixed-reality applications to represent and to exchange functions of physical sensors in 3D scenes. It does not define specific physical interfaces necessary for manipulating physical devices, but rather defines common functional interfaces that can be used interchangeably between applications.

This document does not define how specific applications are implemented with specific physical sensor devices. It does not include computer generated sensor information using computer input/output devices such as a mouse or a keyboard. The sensors in this document represent physical sensor devices in the real world.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
3D object
collection of vertices in 3D space, connected by various geometric entities such as triangles, lines, curved surfaces, etc.

3.2
augmented reality
AR
interactive experience of a real-world environment whereby the objects that reside in the real world are augmented by computer-generated perceptual information

3.3
camera sensor
sensor (3.26) that detects and converts an optical image into an electronic signal

3.4
closed-circuit television
CCTV
video surveillance which uses video cameras to transmit a signal to a specific place on a limited set of monitors

3.5
chemical sensor
sensor (3.26) that can analyse and provide information about the chemical composition of its environment, that is, a liquid or a gas phase

3.6
electric sensor
sensor (3.26) that examines the change in electrical or magnetic signals based on an environmental input

3.7
environment sensor
sensor (3.26) that monitors relative ambient humidity, illuminance, ambient pressure and ambient temperature

3.8
flow sensor
sensor (3.26) for detecting the rate of fluid flow

3.9
force sensor
sensor (3.26) for force detecting resistor whose resistance changes when force or pressure is applied

3.10
globally navigation satellite system
GNSS
satellite navigation system with global coverage

3.11
globally unique identifier
GUID
unique reference number used as an identifier in computer systems

3.12
light sensor
photodetector which detects changes in quantities of optical signal

3.13
mixed and augmented reality
MAR
integration of real and virtual worlds including *mixed reality* (3.14) and *augmented reality* (3.2)

3.14
mixed reality
MR
merging of real and virtual worlds to generate new environments where physical and synthetic objects co-exist and interact

3.15
mixed reality system
system that can process *mixed reality* (3.14) applications with manipulation functions such as read, write, import, export, modify, display, etc.

3.16
movement sensor
detector to detect a change in position of an object relative to its surroundings or the change in the surroundings relative to an object

3.17
oxygen sensor
electronic device that measures the proportion of oxygen (O_2) in the gas or liquid being analysed

3.18
particle sensor
detector to detect, track, and/or identify high-energy particles

3.19
physical device
real device containing a *sensor* (3.26) which is represented by a virtual device in a virtual environment

3.20
physical sensor
Internet of things (IoT) *sensor* (3.26) which has the functionality of a *physical device* (3.19) in a 3D virtual world

3.21
position sensor
sensor (3.26) that permits position measurement

3.22
pressure sensor
sensor (3.26) that measures pressure, typically of gases or liquids

3.23
programmable logic controller
PLC
digital computer used for automation of typically industrial electromechanical processes, such as control of machinery on factory assembly lines, amusement rides, or light fixtures

3.24
proximity sensor
sensor (3.26) able to detect the presence of nearby objects without any physical contact

3.25
radio frequency identification
RFID
wireless use of electromagnetic fields to transfer data, for the purposes of automatically identifying and tracking tags attached to objects

3.26
sensor
device to detect events or changes in its environment and send the information to other electronics

3.27
sound sensor
sensor (3.26) used to detect the sound intensity of the environment

3.28
temperature sensor
sensor (3.26) to detect a change in temperature

3.30
universally unique identifier
UUID
globally unique identifier
128-bit number used to identify information in computer systems

3.32
virtual world
collection of one or more virtual reality (VR) files and other multimedia content that, when interpreted by a VR browser, presents an interactive experience to the user consistent with the author's intent

Note 1 to entry: Virtual reality (VR) is understood as an interactive computer-generated experience taking place in a synthetic and simulated environment.

4 Concepts

4.1 Overview

This clause describes the concepts of sensor-based mixed and augmented reality, including definition, objectives, sensor type, physical sensor representation, system functions for mixed and augmented reality (MAR), MAR objects, MAR scene graph, and MAR world.

A mixed-reality world consists of a 3D virtual world and real-world sensors represented as 3D objects with their physical properties. As a simple example, the conceptual scene of a mixed-reality world is represented in Figure 1. It displays a heritage site represented by a 3D virtual world with a global navigation satellite system (GNSS) sensor and a CCTV sensor. The virtual world is of a real heritage location in a city and the character represents a tourist. GNSS information is displayed for the tourist and a real CCTV device is located at its real physical location at the heritage site.

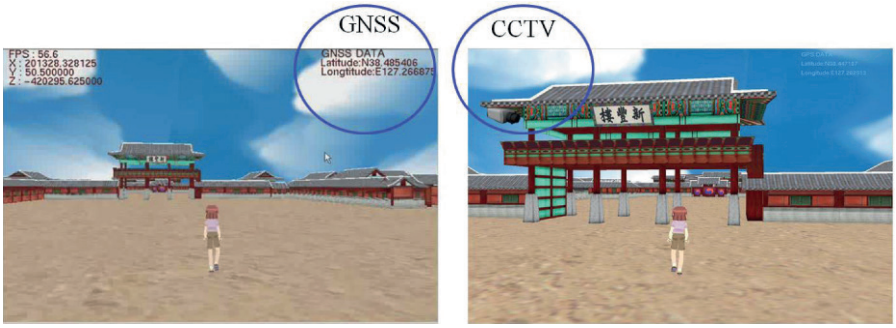

Figure 1 — Example sensor-based mixed-reality world

Once real physical sensors are integrated into a 3D virtual world, their physical properties can be represented precisely in the virtual world. Sensor-based mixed reality is obtained by this convergence of 3D with physical sensors in the real world. For sensor-based mixed reality, sensors in a 3D virtual world are defined, and their information should be able to be transferred between applications, and between a virtual world and a real world. This work is intended to define how to exchange AR/MR application data in heterogeneous computing environments, and how physical sensors can be managed and controlled with their physical properties in a 3D virtual world.

Physical sensors in the real world are many and varied[11][14][18]. In order to control them in a 3D scene, these physical sensors are classified based on their information types and functions. Types of physical sensor devices include acoustic and sound, automotive and transportation, chemical, electric and magnetic, environment and weather, flow and fluid, radiation and particle, navigation, position and angle, speed and acceleration, optical and light, pressure, force and density, thermal and temperature, proximity and presence, and video. Each sensor is represented as a physical device in a 3D scene visually and/or functionally depending on the application and the type of sensor. Figure 2 shows an indoor and an outdoor scene, each with many physical sensors. Each scene represents a corresponding real world. The information and function of each sensor can be represented in the scenes. MAR scenes with physical sensors can be used for representing and simulating the functions of the sensors and, therefore, for managing the sensors using the 3D scene. These can also be used for facility management in a real world[3].

This document focuses on how to represent physical sensors in a 3D scene, what to represent about each physical sensor, what each sensor can do and the reason why each sensor needs this specification. When representing a physical sensor in a 3D scene, having the sensor appear in the scene is optional depending on the type of sensor and the application. Precise location and orientation of a sensor should be able to be represented and units for each sensor should be specified. A 3D scene should be able to be changed by the function of a physical sensor and simulated accordingly. The reason why such representation is needed is to provide a 3D scene with capabilities that can manage and control various physical sensors, for information services or security purposes.

Key

1	camera sensor	4	environment sensor	7	navigation sensor	10	sound sensor
2	chemical sensor	5	flow sensor	8	pressure sensor	11	temperature sensor
3	electric sensor	6	light sensor	9	proximity sensor		

Figure 2 — MAR worlds representation with physical sensors

4.2 Scope of physical sensor representation

Many types of physical sensors are currently in use in the real world and it is expected that the number of sensors and their types will increase with advancements in physical sensor technologies. Physical sensors integrate with 3D virtual worlds by way of information convergence technologies, including mixed and augmented reality. These technologies will be further developed and progressed based

on industry need. While physical sensor devices continue to advance technologically, current sensor devices are being integrated into 3D virtual worlds for use in various real-world simulation applications.

It is not easy and, in fact, unnecessary to define every possible type of sensor that can be integrated into a 3D virtual world because these vary and constantly are updated based on the progression of sensor technology. Although the number of types of physical sensors will increase, a common interface for all sensor types is necessary in order to integrate them with a 3D scene. The interface should have the following features:

— the appearance, properties, location and orientation of a physical sensor should be represented in a 3D virtual world. The 3D virtual world should represent a copied scene of a real world;

— the functions of a physical sensor should be visualized or represented in a 3D virtual world;

— all other sensors that cannot be represented in a 3D virtual world visually and/or functionally are excluded.

In order to provide a 3D virtual world with common physical sensor interfaces, an abstracted physical sensor data model is necessary to represent and simulate these physical sensors[13]. This document defines the data model for representing physical sensors in 3D MAR worlds. The data model defines an abstracted interface that can be used for any type of sensors, not including specific attributes of a particular sensor type such as organization of a data stream.

In this document, the scope of sensor representation includes the following topics:

— concepts of physical sensors in a 3D scene;

— how to represent physical sensors in a 3D scene;

— how to organize a 3D scene with physical sensors;

— how to define an abstract model for representing physical sensors in a 3D scene;

— how to define a system architecture for physical sensors in a 3D scene;

— how to use physical sensors in a 3D scene;

— types of physical sensors for sensor representation.

4.3 Physical sensor types

4.3.1 General

Generally, physical sensors and their related devices can be classified as follows:

— acoustic, sound, vibration;

— automotive, transportation;

— camera, image;

— chemical;

— electric current, electric potential, magnetic, radio;

— environment, weather, moisture, humidity;

— flow, fluid velocity;

— ionizing radiation, subatomic particles;

— navigation instruments;

— position, angle, displacement, distance, speed, acceleration;

— optical, light, photon;

— pressure;

— force, density, level;

— thermal, heat, temperature;

— proximity, presence.

Each sensor type can be defined based on its physical properties and related devices that can be represented and simulated in a 3D virtual world. Typical parameters for the physical properties of each sensor type are described in Annex A. The sensor types are classified (in alphabetical order) in 4.3.2 to 4.3.17.

4.3.2 Camera sensor

This sensor type integrates real world camera and images into a 3D virtual world. A camera sensor is represented as a camera device that converts an optical image into an electronic signal. It is used for digital cameras, phone cameras, camera modules, and other imaging devices, including CCTV (Figure 3). An abstract data model concerning the visual, functional, and physical properties of this sensor type should be defined to represent and simulate them in a 3D virtual world.

Figure 3 — Camera sensors

4.3.3 Chemical sensor

This sensor type integrates real world chemical detection devices into a 3D virtual world. All chemical detection devices, such as smoke detectors, are included. An abstract data model concerning the visual, functional, and physical properties of this sensor type should be defined to represent and simulate them in a 3D virtual world.

A chemical sensor is a self-contained analytical device that provides information about the chemical composition of its environment, that is a liquid or a gas phase (Figure 4). The information is provided in the form of a measurable physical signal that is correlated with the concentration of a certain chemical species (termed an analyte). For example, an oxygen sensor (or lambda sensor) is an electronic device that measures the proportion of oxygen (O_2) in the gas or liquid being analyzed.

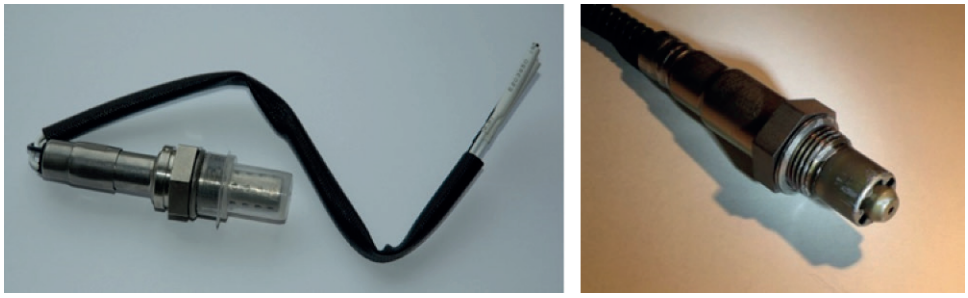

Figure 4 — Chemical sensor (oxygen sensor)

4.3.4 Electric sensor

This sensor type integrates real-world electric and electronic signals into a 3D virtual world. All electrical devices, such as electricity and voltage detectors, are included. An abstract data model concerning the visual, functional and physical properties of this sensor type should be defined to represent and simulate them in a 3D virtual world.

An electric sensor is a manually or automatically operated electrical switch designed to protect an electrical circuit from damage caused by overload or short circuit (Figure 5). Its basic function is to detect a fault condition and interrupt current flow. Unmanned security system and RFID sensors are included.

Figure 5 — Electric sensors

4.3.5 Environment sensor

This sensor type integrates real world environmental change in weather, humidity, barometric air pressure as well as air quality measuring into a 3D virtual world. An abstract data model concerning the visual, functional, and physical properties of this sensor type should be defined to represent and simulate them in a 3D virtual world.

An environment sensor measures and represents earth surface characteristics and supports the information requirements for effective environment management (Figure 6). As a system, the Earth's environment comprises a collection of interdependent elements such as lithosphere, hydrosphere, biosphere, and atmosphere. A single instrument can be used to measure liquids and solids, and granular, slurry or open-channel flow without changing the transducer. Environment sensors can detect dust, gas, humidity, ambient light and weather.

Figure 6 — Environment sensors

4.3.6 Flow sensor

This sensor type integrates real world flow in air and fluid into a 3D virtual world. All flow detectors, such as air flow and fluid sensors, are included. An abstract data model concerning the visual, functional, and physical properties of this sensor type should be defined to represent and simulate them in a 3D virtual world.

A flow sensor is a device that senses the rate of fluid flow. Typically, a flow sensor is the sensing element used in a flow meter, or flow logger, to record the flow of fluids. Flow measurement is necessary for representing the function of a flow sensor. An example of a flow sensor is a water meter (Figure 7). Water metering is the process of measuring water use. Water meters can be used at the water source, at a well or throughout a water system, to determine flow through a particular portion of the system.

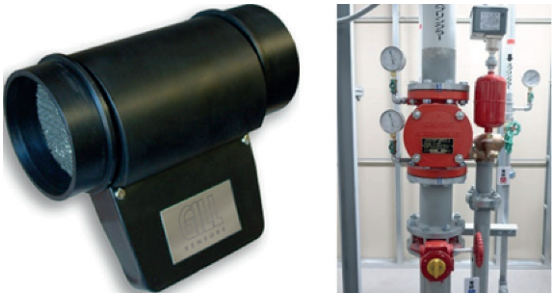

Figure 7 — Flow sensors

4.3.7 Force sensor

This sensor type integrates real-world force, density and level measurements into a 3D virtual world. All force sensors, force transducers and liquid and gas density and level measurement sensors are included. Level sensors detect the level of substances that flow (including liquids), slurries, granular materials and powders. An abstract data model concerning the visual, functional, and physical properties of this sensor type should be defined to represent and simulate them in a 3D virtual world.

A force-sensing resistor is a device whose resistance changes when force or pressure is applied (Figure 8). It is also known as a force-sensitive resistor. Force-sensing resistors consist of a conductive polymer which changes resistance in a predictable manner following application of force to its surface. In a 3D scene, a force sensor device can be represented with some motion based on its functions.

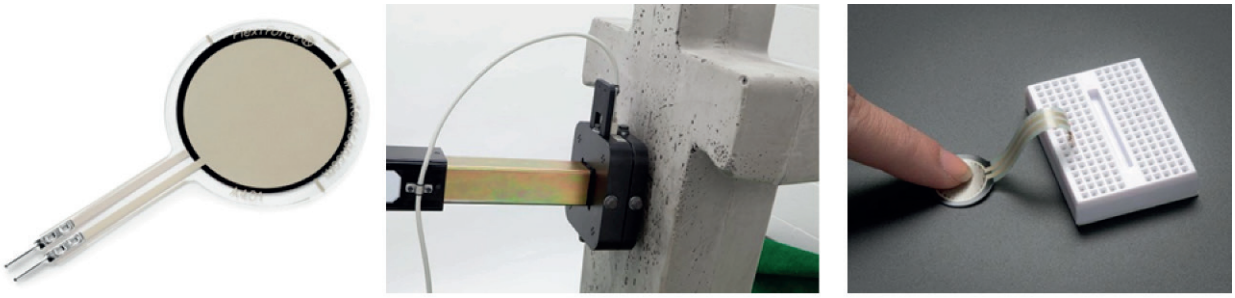

Figure 8 — Force sensors

4.3.8 Light sensor

This sensor type integrates real-world optical, light and photon measurements into a 3D virtual world. All optical, light and photon detectors are included. An abstract data model concerning the visual, functional and physical properties of this sensor type should be defined to represent and simulate them in a 3D virtual world.

A light sensor is a device that is used to detect light. Photosensors or photodetectors are sensors of light or other electromagnetic energy. In this document, a light sensor includes optical detectors and photo resistors, or light-dependent resistors (LDR), which change resistance according to light intensity (Figure 9). In a 3D scene, the light sensor represents the physical intensity of light based on the functions of the device. In a 3D scene, the light sensor itself is not typically represented. Rather, a 3D object that uses a light sensor, such as a light bulb, fluorescent light, or street light, is represented. It is controlled based on the functions of the included light sensor.