DRAFT INTERNATIONAL STANDARD

ISO/IEC DIS 3721-1

ISO/IEC JTC **1**/SC **24** Secretariat: **BSI**

Voting begins on:
2021-09-01

Voting terminates on:
2021-11-24

Information technology — Computer graphics, image processing and environmental data representation — Information model for Mixed and Augmented Reality Contents —

Part 1:
Core Objects and Attributes

ICS: 35.140

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Reference number
ISO/IEC DIS 3721-1:2021(E)

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Published in Switzerland

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Foreword

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ISO/IEC 3721-1 was prepared by Technical Committee ISO/TC JTC 1, *Information technology*, Subcommittee SC 24, *Computer graphics, image processing and environmental data representation*.

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Introduction

Mixed and Augmented Reality (MAR) refers to a spatially coordinated combination of media/ information components that represent, on the one hand the physical real world and its objects and on the other, those that are virtual, synthetic and computer generated. MAR, as an information medium, strives to provide rich experience based on realism, presence and augmentation.

In this standard, a comprehensive set of information constructs for representing Mixed and Augmented Reality contents is described. This set of components extends the conventional ones used for representing virtual reality (VR) contents, as Mixed and Augmented Reality environments are technically realized as virtual environments. The principles and requirements for the extension are laid out and the details of the component model including (but not limited to) those for representing *physical* real world objects, extending the virtual scene graph/structure to that for MAR (with the physical objects), how to spatially the physical objects into the MAR scene graph, associating these content components to the MAR system, and other miscellaneous constructs (e.g. event mapping, MAR events/ behaviours, video backdrops, etc.). The standard is designed for the ease, generality and extendibility, and this is demonstrated with various examples and implementation results. The proposed model will serve as a sound basis for establishing standard and interoperable file formats MAR contents in the future.

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Information technology — Computer graphics, image processing and environmental data representation — Information model for Mixed and Augmented Reality Contents —

Part 1:
Core Objects and Attributes

1 Scope

The objective of this document is to propose an extension to the existing standard for the information model for representing the mixed and augmented reality scene/contents description, namely:

1) Extending the existing and conventional constructs for representing the virtual reality scene graph and structure such that a comprehensive range of mixed and augmented reality contents can also be represented.

2) As part of the extension, representing physical objects in the mixed and augmented reality scene targeted for augmentation.

3) As part of the extension, representing physical objects as augmentation to other (virtual or physical) objects in the mixed and augmented reality scene.

4) Providing ways to spatially associate aforementioned physical objects with the corresponding target objects (virtual or physical) in the mixed and augmented reality scene.

5) Other necessary functionalities and abstractions that will support the dynamic MAR scene description such as event/data mapping, and dynamic augmentation behaviours.

6) Describing the association between these constructs and the MAR system which is responsible for taking and interpreting this information model and rendering/presenting it out through the MAR display device.

The document also provides definitions for terms as related to these MAR content informational components and their attributes.

The target audience of this document are mainly MAR system developers and contents designers interested in specifying MAR contents to be played by an MAR system or browser. The standard will provide a basis for further application standards or file formats for any virtual and mixed reality applications and content representation.

The extension will be self-contained in the sense that it is independent from the existing virtual reality information constructs, focusing only on the mixed and augmented reality aspects.

However, this document only proposes the information model, and neither promotes nor proposes to use a specific language, file format, algorithm, device, implementation method, and standard. The proposed model is to be considered as the minimal basic model that can be extended for other purposed in actual implementation,

2 Normative references

The proposed standard is based on the MAR Reference model (ISO 18039) that specifies for the contents-browser/player type reference architecture. The content (in ISO 18039) is specified as the

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input that describes the scene and objects' behaviours, given to the browser/player which in turn parses, simulates and renders it to the display. The proposed standard is the information model for the content.

As an extension to the virtual reality based contents or scene structure, this standard is very much related to the existing standard for VR scene representation such as the X3D (ISO 19775-1) and other related on-going standards such as the "Image based object/environment representation for VR/MAR (ISO 23488)" as well. There are also specific object models relevant to this standard such as those for the live actors and entities (ISO 18040 and 23490) and MAR system sensor components (ISO 18038).

The following documents are referred to in the text in such a way that some or all of their content constitutes provisions of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendment) applies.

ISO/IEC 18039, *Information technology — Computer graphics, image processing and environmental data representation — Mixed and augmented reality (MAR) reference model*

ISO/IEC 19775-1:2013, *Information technology — Computer graphics, image processing and environmental data representation — Extensible 3D (X3D) — Part 1: Architecture and base components*

ISO/IEC 18040, *Information technology — Computer graphics, image processing and environmental data representation — Live actor and entity representation in mixed and augmented reality (MAR)*

ISO/IEC 23490, *Information technology — Computer graphics and image processing — Information Model for Live Actor and Entity in MAR*

ISO/IEC 18038, *Information technology — Computer graphics, image processing and environmental representation — Sensor representation in mixed and augmented reality*

ISO/IEC NWIP 23488, *Information technology — Computer graphics and image processing — Image based object/environment representation for VR/MAR*

3 Terms and definitions

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

3.1 Technical terms as already defined in the other related standards

3.2
augmentation
virtual object data (computer-generated, synthetic) added on to or associated with *target physical world/object* data (live video, real world image) in a *MAR scene*. Equally applies to *physical object* data added on to or associated with target *virtual world/object data*.

[SOURCE: ISO/IEC 18039:2019, definition 3.1]

3.3
augmented reality system
type of *mixed reality system* in which *virtual world/object* data are embedded and/or registered with the representation of *physical world* data

[SOURCE: ISO/IEC 18039:2019, definition 3.2]

3.4
augmented virtuality system
type of *mixed reality system* in which *physical world/object* data are embedded and/or registered with the representation of *virtual world* data

[SOURCE: ISO/IEC 18039:2019, definition 3.3]

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3.5
display
device by which rendering results are presented to user. It can use various modalities such as visual, auditory, haptics, olfactory, thermal, motion. In addition, any actuator can be considered display if it is controlled by the MAR system.

[SOURCE: ISO/IEC 18039:2019, definition 3.4]

3.6
feature
primitive geometric elements (e.g. points, lines, polygons, colour, texture, shapes) and/or attributes of a given (usually physical) object used in its detection, recognition and tracking

[SOURCE: ISO/IEC 18039:2019, definition 3.5]

3.7
live actor and entity (LAE)
A representation of a living physical or real object, such as a human being, animal, or bird, in the MAR content or system. A live actor can be animated, moved, and interacted with virtual objects in a MAR scene by capturing gesture from a camera. Entity

[SOURCE: ISO/IEC 18040: definition 3.1.10]

3.8
MAR event
trigger resulting from the detection of a condition relevant to MAR content and augmentation (e.g. detection of a *marker*)

[SOURCE: ISO/IEC 18039:2019, definition 3.6]

3.9
MAR execution engine
collection of hardware and software elements that produce the result of combining components that represent on the one hand the physical world/objects, and on the other those that are virtual, synthetic and computer generated

[SOURCE: ISO/IEC 18039:2019, definition 3.7]

3.10
MAR experience
human visualization and interaction of a *MAR scene*

[SOURCE: ISO/IEC 18039:2019, definition 3.8]

3.11
MAR scene (synonymous to MAR content)
observable spatio-temporal organization of physical and virtual objects. This is the result of a MAR scene representation being interpreted by a MAR execution engine. A MAR scene has at least one physical and one virtual object

[SOURCE: ISO/IEC 18039:2019, definition 3.9]

3.12
MAR scene representation (or scene graph)
data structure that arranges the logical and spatial representation of a graphical scene including the *physical and virtual objects* that is used by the MAR execution engine to produce a MAR scene

[SOURCE: ISO/IEC 18039:2019, definition 3.10]

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3.13
marker
meta data embedded in or associated with a physical object that specifies the location of a superimposed object.

[SOURCE: ISO/IEC 18039:2019, definition 3.11]

3.14
mixed and augmented reality (MAR) system
Term that is synonymous with *mixed reality system*[1)].

[SOURCE: ISO/IEC 18039:2019, definition 3.12]

3.15
mixed reality system
system that uses a mixture of representations of *physical world* data and *virtual world* data as its presentation medium

[SOURCE: ISO/IEC 18039:2019, definition 3.14]

3.16
natural feature
feature that is not artificially inserted for the purpose of easy detection/recognition/tracking

[SOURCE: ISO/IEC 18039:2019, definition 3.15]

3.17
physical object
object that exists in the physical real world. It is also often referred to as a *real object* or *real world object*

[SOURCE: ISO/IEC 18039:2019, definition 3.16]

3.18
physical reality
term synonymous to *physical world* itself or medium that represents the *physical world* (e.g. live video or raw image of real world)

[SOURCE: ISO/IEC 18039:2019, definition 3.17]

3.19
physical world
spatial organization of multiple *physical objects*

[SOURCE: ISO/IEC 18039:2019, definition 3.18]

3.20
point of interest
single or collection of target locations. Aside from location data, a point of interest is usually associated with meta data such as identifier and other location specific information.

[SOURCE: ISO/IEC 18039:2019, definition 3.19]

3.21
recognizer
MAR component (hardware and software) that processes *sensor* output and generates *MAR events* based on conditions indicated by the content creator

[SOURCE: ISO/IEC 18039:2019, definition 3.20]

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1) The word “augmented” is often used together with the word “mixed”.

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3.22
sensor
device that returns detected values related to detected or measured condition or property. Sensor may be an aggregate of sensors.

[SOURCE: ISO/IEC 18039:2019, definition 3.21]

3.23
spatial registration
establishment of the spatial relationship or mapping between two models, typically between *virtual object* and target *physical object*

[SOURCE: ISO/IEC 18039:2019, definition 3.22]

3.24
target image
target object represented by a 2D image

[SOURCE: ISO/IEC 18039:2019, definition 3.23]

3.25
target object
physical or virtual object that is designated, designed or chosen to allow detection, recognition and tracking, and finally augmentation

[SOURCE: ISO/IEC 18039:2019, definition 3.24]

3.26
tracker
MAR component (hardware and software) that analyses signals from *sensors* and provides some characteristics of tracked entity (e.g. position, orientation, amplitude, profile)

[SOURCE: ISO/IEC 18039:2019, definition 3.25]

3.27
virtual object
computer-generated entity that is designated for augmentation in association with a *physical object* data representation. In context of MAR, it usually has perceptual (e.g. visual, aural) characteristics and, optionally, dynamic reactive behaviour

[SOURCE: ISO/IEC 18039:2019, definition 3.26]

3.28
virtual world or virtual environment
spatial organization of multiple *virtual objects*, potentially including global behaviour

[SOURCE: ISO/IEC 18039:2019, definition 3.27]

3.2 Technical terms as newly defined or used in this standard

3.2.1
aggregation (as defined and used in the Unified Modelling Language literature)
a relation among objects/components that specifies a whole-part relationship

3.2.2
association (as defined and used in the Unified Modelling Language literature)
a relation among objects/components (and their instances) that they can be linked to each other or combined logically or physically into some aggregation (i.e. aggregation is a specific form of an association)

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3.2.3
behaviour
an *object* or *component* that describes how certain objects and their attribute values change in time and/or in response to *events*

3.2.4
content (or MAR content, synonymous to MAR scene)
a description of (mixed and augmented reality based) experience to end-users by publishers or media producers

3.2.5
component/object (or MAR component/object)
a self-contained computational entity or model that has one or more input channels and/or one or more output channels. a synonym to an *object* (as referred in the general computer science literature). in the context of MAR contents or system, a component has a relevant MAR functionality

3.2.6
event mapping
an *object* or *component* that maps events produced by the *MAR system* and maps/relates them to the corresponding ones in the *MAR scene/content* space

3.2.7
glass-based
a type of an optical see-through device that has the form factor of optical glasses

3.2.8
inheritance (as defined and used in the Unified Modelling Language literature)
an *association* representing a parent and child relationship. in general, the child object, if not specified otherwise, will inherit the attribute model of the parent

3.2.9
node
a term referred to an actual implementation or specific format of an *object* or *component*

3.2.10
object (component) model
a model of a collection of computational *objects* and their relationships serving a particular purpose or collective function. synonymous to a *component model*

3.2.11
optical see-through device
an apparatus or device that allows the *real/physical world* to be seen directly or through optical elements (lenses). in addition, the device allows an overlaid display of graphical (or *virtual*) elements

3.2.12
real object
a synonym to a *physical object*

3.2.13
real transform group (RTG)
a transform group representing a group of objects situated at a *physical/real* spatial location

3.2.14
transform
an abstract entity representing a relative spatial relationship (translation, rotation and scaling) with another coordinate system (or equally *transform*)

3.2.15
transform group (TG)
a component or object that represents group of *objects* or components sharing a common physical or virtual coordinate system

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3.2.16
video see-through device
an apparatus or device that displays the *real/physical wor*ld live through a video camera feed

3.2.17
virtual transform group (VTG)
a *transform group* representing a group of *objects* situated at a *virtual* spatial location

3.3 Acronyms and abbreviated terms Table of abbreviated terms

Table 1 shows a list of abbreviated terms used in this document.

Table 1 — Abbreviated terms used in this document

Abbreviation	Terms
AR	Augmented Reality
CRT	Capturer, Recognizer, Tracker
GNSS	Global Navigation Satellite System
LAE	Live Actor and Entity
MAR	Mixed and Augmented Reality
MAR-RM	Mixed and Augmented Reality Reference Model
MR	Mixed Reality
UI	User Interface
VR	Virtual Reality
RTG	Real Transform Group
TG	Transform Group
VTG	Virtual Transform Group

4 Overview

Mixed and Augmented Reality (MAR) refers to the interactive medium that uses and merges the real (or physical) and virtual objects [Milgram]. The two representative genres of MAR are the "augmented reality (AR)" where virtual objects are added on to representation of the real physical world, while in the "augmented virtuality (AVR)," real world physical object representations are added to the virtual environment. The continued innovations and advances in computer vision, mobile/cloud computing and portable display devices have brought about a renewed interest in MAR, as a prominent information visualization and interaction medium. MAR not only has many application areas but also can empower users in daily activities by spatially augmenting useful information to key interaction objects. Traditionally, MAR services/contents have been developed as a single application using popular application programming interfaces (APIs). While there are moves to standardize the API [WebXR] [OpenXR], there is also a strong and natural move toward the separation of such singleton applications into contents (in some standard formats) and dedicated players/browsers, similarly to those for web documents.

X3D already offers a standard and declarative method of specifying dynamic virtual environments [ISO/IEC 19775] and is in fact being extended for MAR functionalities [X3D MAR WG]. Such a service structure (and standards) can promote the proliferation of the given media and associated content form. Thus, in this standard, we propose a minimal (yet able to cover a comprehensive and reasonable, typical MAR contents) set of information constructs for representing MAR contents. The standard would extend the conventional constructs used for representing virtual reality contents (such as X3D), as virtual environments are used for the implementation platform for mixed reality contents as well.

First, the principles and requirements for the extension are laid out and the details of the component model including (but not limited to) those for representing real world physical objects, extending the virtual scene graph/structure to that for MAR (with the real objects), how to spatially the real

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