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BSI Group Headquarters

389 Chiswick High Road London W4 4AL

Tel: +44 (0)20 8996 9000

Fax: +44 (0)20 8996 7400

www.bsigroup.com

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Introduction

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1	2	(3)	4	5	(6)	7
MB	Clause No./ Subclause No./Annex (e.g. 3.1)	Paragraph/ Figure/Table/Note	Type of comment	Comment (justification for change) by the MB	Proposed change by the MB	Secretariat observations on each comment submitted
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	



DRAFT International Standard

ISO/IEC DIS 20538

Information technology — Computer Graphics, image processing and environmental data representation — Human information data model for VR- based smart cities

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CP 401 • Ch. de Blandonnet 8
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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 <https://www.iso.org/directives> or https://www.iec.ch/members_experts/refdocs).

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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) see <https://www.iso.org/iso/foreword.html>. In the IEC, see <https://www.iec.ch/understanding-standards>.

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

Introduction

This document defines the concept of a human information data model that represents human information in a 3D virtual smart city. The human information data model includes its visual information, semantic properties related to human information, physical properties, and physical sensor information obtained from sensors for representing human information in a 3D virtual environment. This document contains the following:

- Terms, definitions, and concepts of a human information data model for a 3D virtual smart city
- Requirements for a human information data model for a 3D virtual smart city
- Definition of human information that can be specified in a 3D virtual smart city
- Representation of human-related information including sensor information that can be represented in a 3D virtual smart city
- Functionalities and base components for a human information data model for a 3D virtual smart city
- Use cases

The objectives of this document are as follows:

- Provide a reference model for human information representation in a 3D virtual smart city
- Provide a reference model to manage and monitor human information with sensors in a 3D virtual smart city
- Provide a method of defining and representing exchangeable information for developing human-related information applications in mixed and augmented reality

Information technology — Computer Graphics, image processing and environmental data representation — Human information data model for VR-based smart cities

1 Scope

This document defines a data model for representing human information including sensor information in a 3D virtual environment that simulates a real smart city. It includes concepts, a data model, and how to integrate human information with sensors into a 3D virtual smart city. It specifies an exchangeable information data model necessary for transferring and storing human information in a 3D virtual smart city.

This document includes the following functionalities:

- a) Representation of human information in a 3D virtual smart city
- b) Representation of human information with sensors in a 3D virtual smart city
- c) Representation of human semantic and physiological information for a 3D virtual smart city
- d) Definition of an interchangeable data model for human information for a Virtual smart city

This document does not define specific physical interfaces necessary for manipulating sensor devices, but rather defines common functional data interfaces that can be used interchangeably between applications.

This document does not define how specific applications are implemented with specific 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 the functions of human related devices in the real world in relation to 3D data models for a 3D virtual smart city.

2 Normative references

This document shall be based on the following documents of which their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC 18038:2020, *Information technology — Computer graphics, image processing and environmental representation — Sensor representation in mixed and augmented reality*

ISO/IEC 19774-1:2019, *Information technology — Computer graphics, image processing and environmental data representation — Part 1: Humanoid animation (HAnim) architecture*

ISO/IEC 19774-2:2019, *Information technology — Computer graphics, image processing and environmental data representation — Part 2: Humanoid animation (HAnim) motion data animation*

3 Terms, definitions, acronyms, and abbreviations

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 <https://www.electropedia.org/>

3.1 Terms and definitions

3.1.1

3D object

collection of polygons in 3D space, connected by various geometric entities such as vertices, edges, plain faces, curved surfaces, etc.

3.1.2

Body Mass Index

BMI

simple index of weight-for-height that is commonly used to classify underweight, overweight and obesity in adults and defined as the weight in kilograms divided by the square of the height in meters (kg/m^2)

[SOURCE: ISO 21856:2022(en), 3.7]

3.1.3

Electrocardiogram

ECG

dominant cardiac monitoring technique to identify cardiovascular abnormalities and to detect irregularities in heart rhythms

3.1.4

head-mounted display

HMD

display device, worn directly on the head or as part of a helmet that places a small display optic in front of each eye

3.1.5

health parameter

health indicator that can represent the status of human health

3.1.6

human anatomy

biological science that concerns the discovery, analysis, and representation of the structural organization of the human body

[SOURCE: ISO 1828:2012(en), 3.8.2]

3.1.7

human information

human related information that can represent appearance, physical properties, and semantic properties

3.1.8

informative avatar

avatar that is represented by and includes appearance, semantic properties, and physiological properties

3.1.9

physical material

material that makes up a physical object can be used for specifying physical properties and for representing haptic perception.

3.1.10

physical property

property relating to that which is material or digital input from the real world such as sensor information, for an object

3.1.11

physical sensor

IoT sensor which has the functionality of a physical device in a 3D virtual world

[SOURCE: ISO/IEC 18038:2020(en)]

3.1.12

physiological property

property of a living organism that is related to the organism's bodily function

3.1.13

polygon

closed plane figure, having three or more, usually straight, or sides

3.1.14

semantic property

property that contributes to the function or meaning of an object, and that has aspects of a linguistic unit, such as a morpheme, word, or sentence

3.1.15

smart glass

switchable glass that can change its optical properties, becoming opaque or tinted, in response to electrical and thermal signals

3.1.16

virtual environment

interactive and immersive computing environment where 2D, 3D, or 4D virtual objects can exist in a scene

3.1.17

virtual human

digital human that refers to a computer-generated three-dimensional (3D) character which looks and behaves like a human; a virtual human represents a real person in the virtual world.

3.1.18

virtual smart city

replicated smart city that is represented and simulated in a 3D virtual environment using VR technologies

3.1.19

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

[SOURCE: ISO/IEC 18038:2019(en), 3.32]

3.1.20

visual material

material that can be used for specifying visual properties with color, transparency, and other visual effects

3.1.21

wearable device

gadget such as a smartwatch, fitness tracker, and smart glasses, that can be worn on the human body for such purposes as accessing information and tracking health.

3.1.22

visual property

characteristic or quality that can be seen; refers to features that affect how something appears to the eyes, such as color, shape, size, brightness, and texture; in computer graphics, includes geometric and appearance information.

3.2 Acronyms and abbreviations

[Table 3.1](#) lists the abbreviated terms used in this document.

Table 3.1 — Abbreviated terms

Abbreviation	Abbreviated term
2D	2- dimensional
3D	3-dimensional
4D	4-dimensional
AR	Augmented Reality
BMI	Body Mass Index
ECG	Electrocardiogram
GNSS	Global Navigation Satellite System
HAnim	Humanoid Animation
HMD	Head-mounted display
IoT	Internet of Things
ID	Identifier
IP	Internet Protocol
MAR	Mixed and Augmented Reality
MR	Mixed Reality
VE	Virtual Environment
VR	Virtual Reality
XML	Extensible Markup Language

4 Concepts

4.1 General

VR-based smart cities should provide for monitoring and management of human information data of real city resident.^[1] To achieve this, human information should be able to be collected, represented and managed for a virtual smart city in a way that simulates real city functionally. This clause defines concepts for representing human information and how to organize that information in relation to a virtual environment that corresponds to a smart city. For example, human information can be represented and monitored in a virtual smart city that provides the functionality of a smart health system (Figure 4.1).

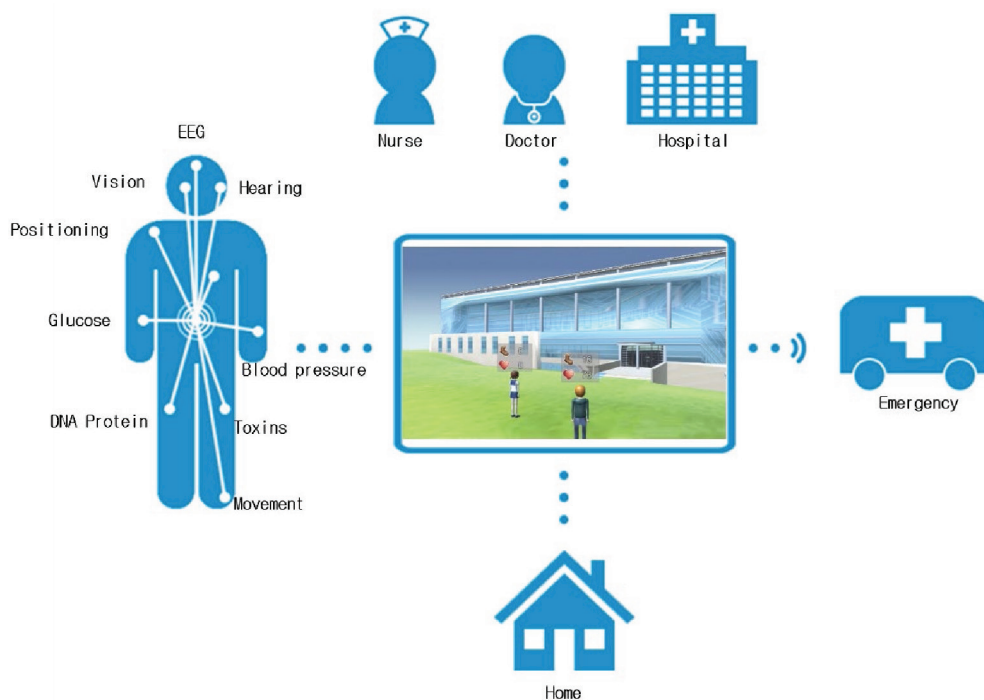


Figure 4.1 — Human information for smart health

4.2 Virtual smart city

A virtual smart city represents a smart city visually and functionally in a 3D VR environment. That is to say, a virtual smart city depicts a copy of a real smart city, and the functions and information of the smart city are represented therein. A virtual smart city consists of a virtual environment, virtual objects and virtual humans. Virtual objects include all things that can be represented in a virtual environment including sensor devices. Wearable devices such as HMDs and smart glasses are examples of virtual objects that are sensors of human information in a virtual environment.

4.3 Human information in a virtual smart city

Human information includes physical, semantic, and health information of a human. This information should be able to be retrieved, stored, and transferred in the virtual environment. [Figure 4.2](#) shows an example scene of representing and managing human information in a virtual environment where a real location that includes a building is represented as part of a virtual smart city. In this example, human information parameters such as the number of steps taken, heart rate, and GNSS information can be monitored through the virtual world.



Figure 4.2 — Representation of human information in a 3D virtual smart city

4.4 A data model for representing human information

To represent human information in a 3D virtual smart city, five modelling components should be specified ([Figure 4.3](#)). These are a 3D virtual environment, a 3D virtual human, human physiological property, and sensors. All data relevant to these components should be structured and interrelated to facilitate the generation and retrieval of human related information in the virtual smart city from anywhere. A data model to define the components is necessary to define relevant information for representing and managing human information in a virtual smart city. [Clause 5](#) describes details of the data model.

Human health information in a smart city can be managed and monitored using a virtual environment with sensors or wearable devices. ISO/IEC 18038 defines sensor representation in mixed and augmented reality. It defines a data model for representing sensors and communicating information in a 3D virtual environment. The data model in this document extends to human information related health sensors and wearable devices which can be represented in a sensor based virtual environment defined in ISO/IEC 18038. Human information monitored by health sensors and wearable devices can be defined along with a human data model with sensors in the virtual environment.

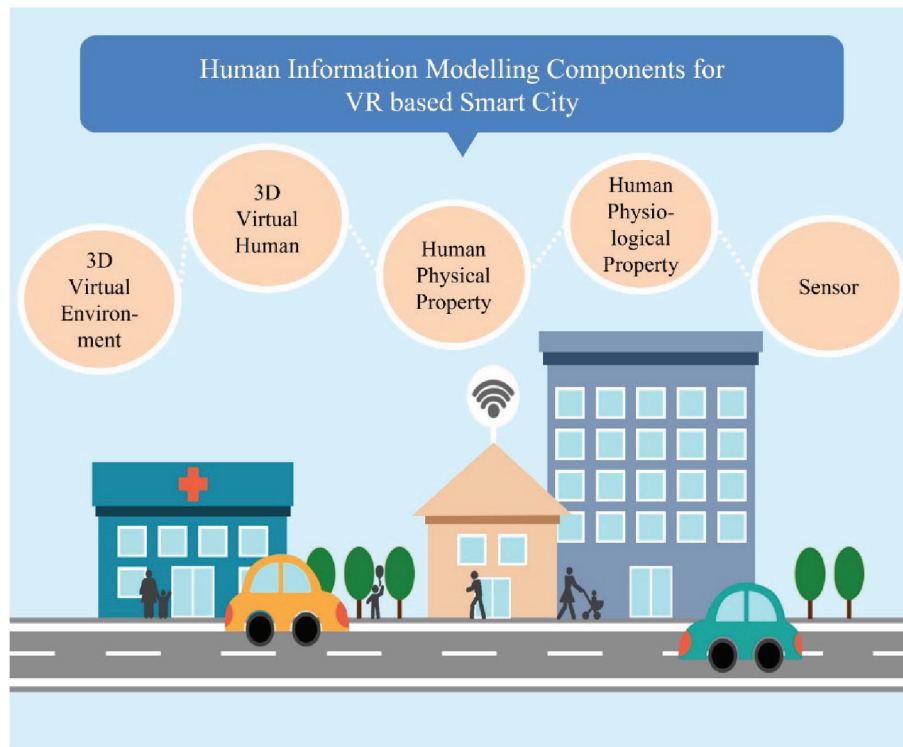


Figure 4.3 — Human information modeling components for VR based smart city

4.5 Human information sensors

Human information sensors are of various types to support the detection of physiological signals, human activities, and environment conditions ([Figure 4.4](#)). Some types of sensors are embedded in wearables such as glasses, watches or clothing. Sensors monitor the position, health condition or safety of humans. They can facilitate the detection of disability.



Figure 4.4 — Human information sensors

5 Requirements for human information representation in a 3D virtual environment

5.1 General

For an informative human avatar to be represented and managed in a 3D virtual environment for a virtual smart city, virtual environment, virtual object, human object, physical properties, semantic properties, physiological properties, human anatomy systems and related information, and physical sensor information

should be able to be represented. The following subclauses specify the requirements for representing these components for a virtual smart city.

5.2 Virtual environment

A virtual environment shall be defined with visual properties, physical properties, and semantic properties in relation to human information. Visual properties include geometric and appearance information required to represent a human. These visual properties can be specified using ISO/IEC 18038. Physical properties specify physical information such as physical materials, length, weight, temperature, humidity, etc. Semantic properties include functional properties or meaningful descriptions for virtual objects in a virtual environment.

A virtual avatar with human information should be able to be defined and recognized in the virtual environment. Not just visual information but also semantic information should be able to be included directly in the virtual environment. Location and orientation of the avatar should also be able to be maintained in relation to the virtual environment. Geo-location of the virtual environment and the avatar should coincide with the real environment.

5.3 Human object

Human objects or avatars should be able to be represented in the virtual environment as a way for human information to be included and managed. Human information should be able to be represented as visual properties, physical properties, physiological properties, and semantic properties. Visual properties specify geometric and material properties that are necessary to represent a human object in a virtual environment as virtual objects. For visual properties, human motion should also be able to be specified based on hierarchical human skeleton structures that affect human motion. ISO/IEC 19774-1 and ISO/IEC 19774-2 can be used to represent human motion with visual properties.

Depending on the application, and particularly those in health and medical areas, human anatomy systems should also be able to be included. Human appearance should be able to be represented in the 3D virtual world, usually with visual property. This is defined in accordance with the geometric shape and materials for the representation of the human. The human in relation to the corresponding location and orientation to the real world should be able to be defined in the virtual world.

5.4 Human semantic information

Human semantic information specifies human specific properties that characterize a person. It includes human related information such as name, gender, interests, job, etc. Human semantic information should be able to be included in relation to the avatar representation. This means that a human avatar should be able to be represented with its semantic information wherever they exist in a virtual environment.

5.5 Human physiological information

Human physiological information specifies human health information such as height, weight, temperature, heart rate, blood pressure, blood glucose, and blood cholesterol ([Figure 5.1](#)). This information can be expanded depending on the complexity of detail required in various use cases. Human physiological information should be able to be managed and monitored visually in a 3D virtual environment with position and orientation information of a virtual human representing a person in the real world. With this information, a person's health information can be monitored through a virtual environment representing a real world.

5.6 Human anatomy systems

The ability to represent human anatomy systems in a virtual environment is required because these are key components of human health. Clinical and health areas, for example, would require the representation of these systems so that health information can be managed using a virtual environment. In this document, six human anatomy systems are considered: skeletal system, respiratory system, muscular system, digestive

system, cardiovascular system, and urinary system (Figure 5.2). This can be extended to include other systems depending on the use case.

Human anatomy systems are not always necessary to represent human information in a virtual environment, so they can be used optionally or selectively depending on the application. The data model for human information should be designed so that human information can be represented in various levels of detail according to the application type.

5.7 Human physical sensors

Many types of physical sensors can be used to obtain physical and physiological information of a human. These include smart phone sensors, medical and health sensors, wearable device sensors, and personal vehicle-based sensors such as bike sensors. These sensors detect human related information such as location, orientation, vision, touch, health, etc. Sensor data for a person should be able to be maintained in the virtual world while the person moves around the real world. Sensor data in relation to a human should be able to be collected and represented synchronously with spatial and temporal information from sensor devices.

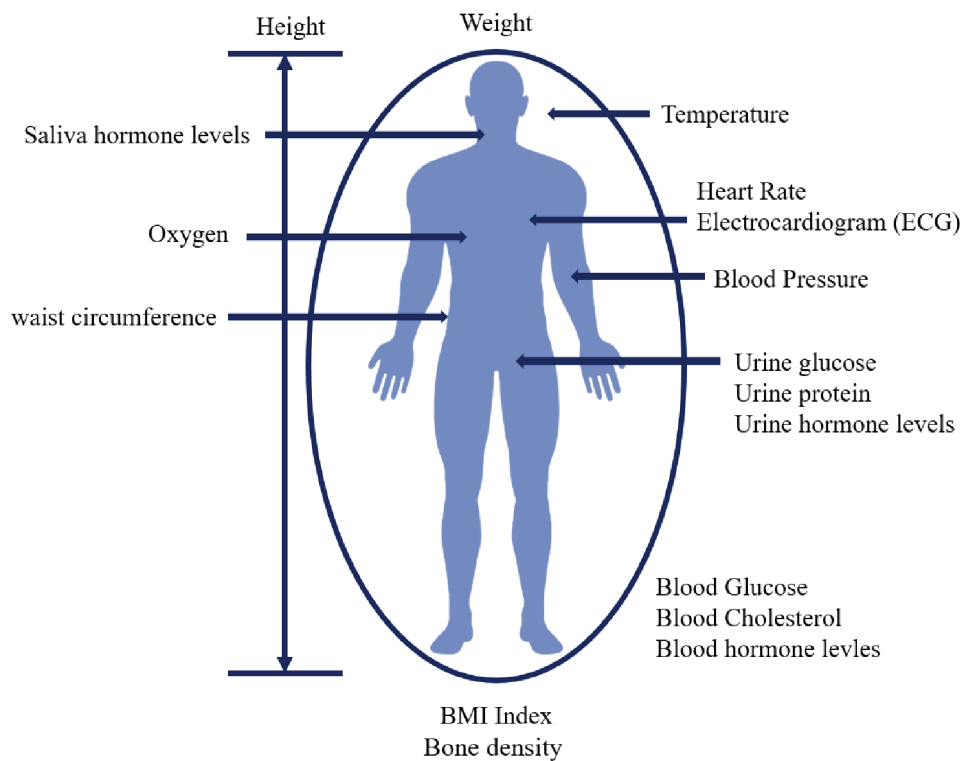


Figure 5.1 — Human physiological information

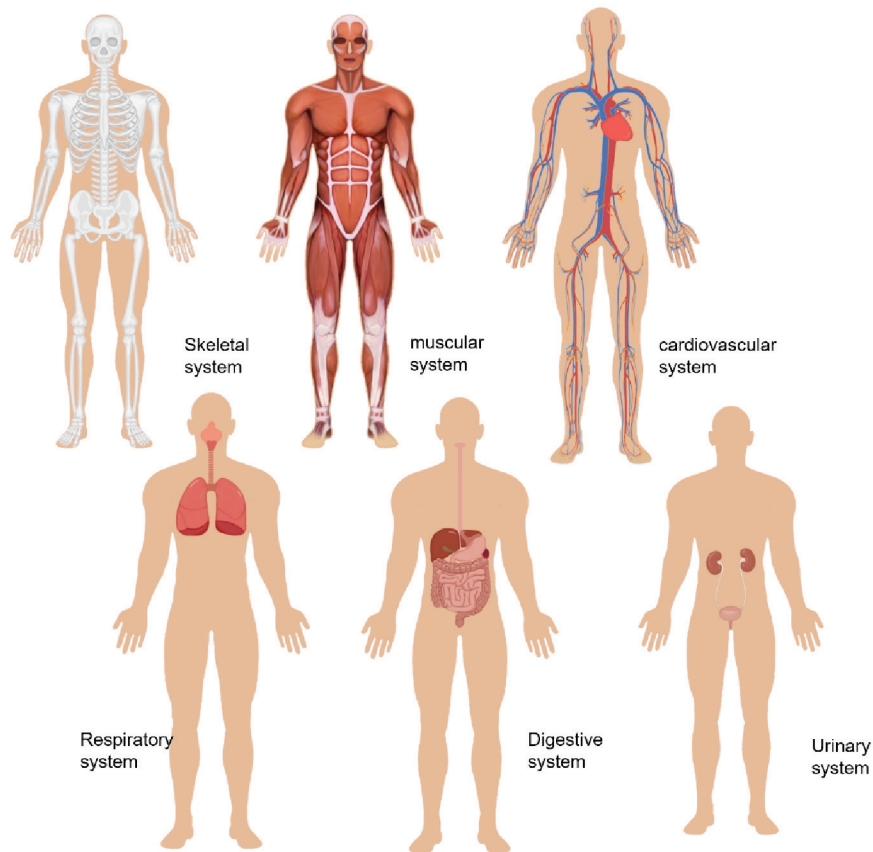


Figure 5.2 — Human anatomy systems

6 Human information data model

6.1 General

This clause describes the hierarchical data model for human information representation in a 3D MAR virtual environment, and the extension of human information by incorporating humans into the virtual environment. The human information data model is defined based on the 3D scene hierarchy of a VR based smart city using ISO/IEC 18038 that specifies sensor representation in mixed and augmented reality. The data model includes human physiological property and semantic property based on the hierarchical human data structure and motion data definition for visual property specified in ISO/IEC 19774-1 and ISO/IEC 19774-2.

6.2 Representation of human information

In order to monitor and manage human information in a 3D virtual smart city, human information of a real person including appearance, motion, physical, physiological, and semantic properties should be able to be represented and managed in a virtual environment. A data model is necessary in order to define, manipulate, store, and exchange human information in relation to the person located in the virtual world. The data model shall include information that is necessary to provide the following functionalities:

- Representation of a 3D virtual environment: A 3D data model is required to define a virtual environment. Visual, physical, and semantic properties should be able to be included. When sensors are used, they should be able to be represented in the virtual environment.
- Representation of a 3D human model: A 3D human model is required to visually define a virtual human that represents a person in a 3D virtual environment. The human model should be able to specify hierarchical data structures for a human and its motion in the virtual environment.

- Representation of human physical properties in a 3D virtual environment: A data model is required to define human physical information that constitutes a person's characteristics, such as height, weight, interests, job, etc.
- Representation of human physiological information in a 3D virtual environment: A data model is required to define human physiological information that specifies human health.
- Representation of human semantic information in a 3D virtual environment: A data model is required to define human semantic information that specifies a functional description of a human.
- Representation of human related device sensor information: A 3D sensor data model is required to define sensors in a 3D virtual smart city. These include smartphones and health related sensors that can obtain human information while a person is carrying the sensor device or has it attached to its person (e.g. wearable devices).

6.3 Human information data model

[Figure 6.1](#), [Figure 6.2](#), and [Figure 6.3](#) show the basic data structures and relationships for the above representations of to define the human data model. These hierarchical data structures are defined by extending ISO/IEC 18038. This document defines the human data model in a virtual environment and includes the following components:

- A 3D virtual smart city is added to the MR scene node as a root ([Figure 6.1](#)). An MR scene consists of an MR object, and a human object in addition to geo-origin, geo-bounding box, and orientation (see ISO/IEC 18038). A set of MR objects and human objects can be defined in a virtual environment aligned with the information of the geo-origin, geo-bounding box, and orientation. Geo-origin refers to the origin of a geo-bounding box that locates a virtual environment. The virtual environment for a 3D scene is located by the geo-origin and the orientation in the geo-bounding box.
- An MR object consists of shape, physical properties, and physical sensor ([Figure 6.2](#)). The shape has information about geometry, material, and interface with the virtual world that represents the appearance and interaction of the MR object in the 3D virtual environment. Physical properties define physical characteristics for the MR object. It includes real size, length, weight, material properties such as plastic or glass, etc. An MR object can include a physical sensor that has properties of location and orientation, sensor type, shape, physical properties, and physical interface with the real worlds. Physical interfaces include ones for import / export of real-world information through the sensors or devices. Other semantic information such as usage or function can also be defined in physical properties. A camera sensor in a building is an example of a physical sensor.
- A 3D human object node is added to specify information of each person in the virtual environment ([Figure 6.3](#)). This information includes shape, semantic properties, physiological properties, human anatomy systems, and physical sensors. The shape has information about geometry, visual material, and interface with the virtual world that represents the appearance and interaction of the human object in the 3D virtual environment. Physiological properties include health related information. Examples of physiological properties are temperature, heart rate, blood pressure, blood glucose, body fat, cholesterol, vision, hearing, etc. Semantic properties are properties other than physiological properties of a human such as name, occupation, interests, relationships with other people, emotions, etc. Physical material such as haptic perception can also be included in semantic properties. Physical sensors have properties of location and orientation, sensor type, shape, physical properties, and physical interface with the real world for human information.
- A human object can have information about the human anatomy systems would be required for medical applications in order to describe medical details for informing of and prescribing for the health status of a person or a specific body part. Human anatomy systems consist of skeletal, respiratory, muscular, digestive, cardiovascular, and urinary system information. Other anatomy systems can also be included depending on the application or area. Each system has components of shape, physiological properties, and physical sensors. Shape has information about geometry, material, and interface with the virtual world that represents the appearance and interaction of the human anatomy in the 3D virtual environment. Physiological properties include health information related to each human anatomy system. Physical

sensors include properties of location and orientation, sensor type, shape, physical properties, and physical interface with the real world for a human anatomy system.

- A human object can have basic health information that in many instances is easily obtained from wearable sensor devices. This information includes height, weight, heart rate, pressure, blood glucose, etc. as illustrated in [Figure 5.1](#). This data can be managed and monitored using medical or health sensors or from medical examinations in relation to the virtual environment. These physiological properties can be represented under a human object and/or each anatomy system.

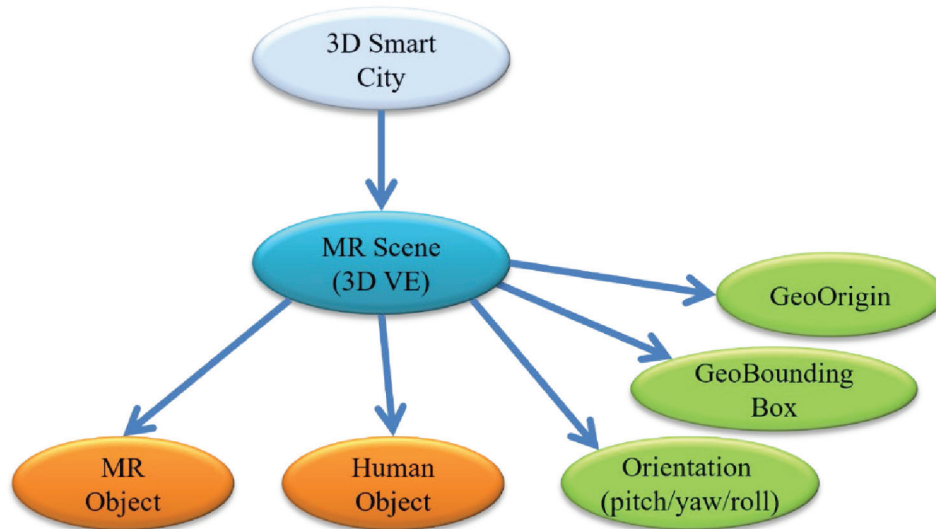


Figure 6.1 — 3D smart city data model

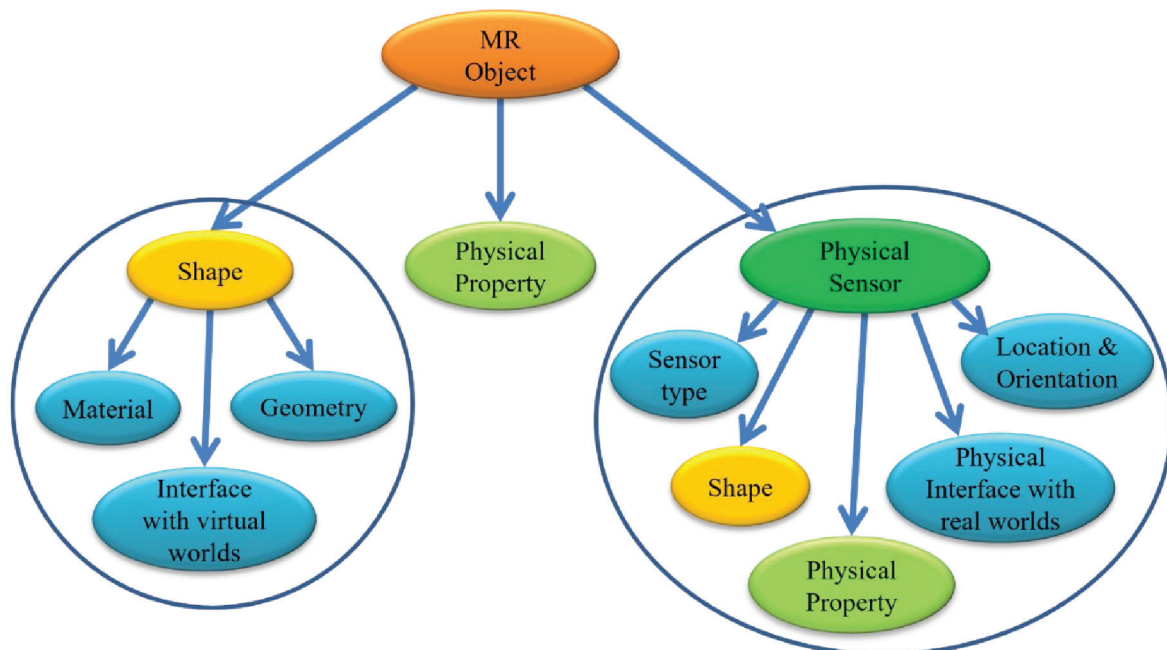


Figure 6.2 — MR object data model

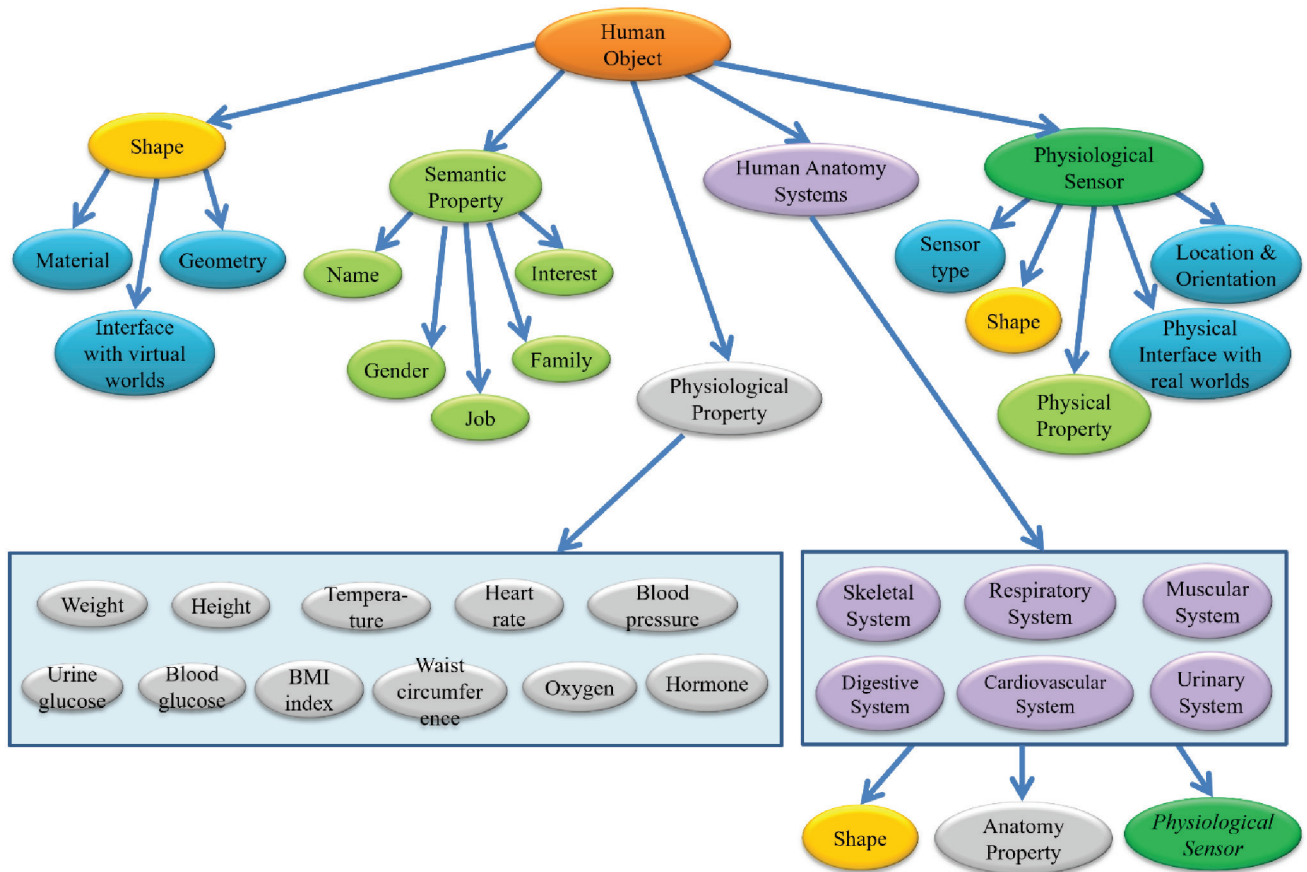


Figure 6.3 — Human object data model

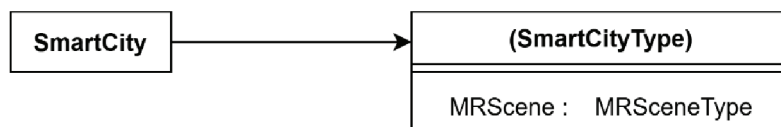
7 XML definition of human information with sensors

7.1 General

This clause specifies an XML schema that can be used to define human information in a 3D virtual environment with sensor representation for a smart city. Data structure and types for human information are defined based on the scene data modelling shown above in [Figure 6.1](#), [Figure 6.2](#), and [Figure 6.3](#).

7.2 SmartCity Type

SmartCityType contains information to be represented as a virtual environment with sensors for a 3D VR based smart city. It consists of one or more MR scenes. It is the highest node that includes virtual environments and human avatars. The following diagram shows the composition and relationship with the 3D smart city:



The XML schema for the 3D smart city is defined as follows:

```

<!-- Root element -->
<element name="SmartCity">
  <complexType>
    <sequence>
      <element name="MRScene" type="h:MRSceneType"
        minOccurs="0" maxOccurs="unbounded" />
    </sequence>
  </complexType>
</element>

```

7.3 MRScene Type

MRSceneType is defined with MR objects, human objects, location and orientation in a 3D virtual environment (Figure 6.1). MR objects represent all environment objects, and human objects represent virtual humans or avatars. For the location and orientation for an MR object or human object, geo-origin, geo-boundingbox, and orientation are defined. An MR scene should be defined prior to defining a virtual human. Then, the human is positioned in the MR scene. The location is specified with origin and a bounding box that represents a geographic spatial region for the virtual environment. The following shows the composition and relationship with the MR scene:

MRSceneType	
GeoOrigin :	GeoPositionType
GeoBoundingBox :	GeoBoundingBoxType
Orientation :	OrientationType
MRObjct :	MRObjctType
HumanObject :	HumanObjectType

The XML schema for the MR scene is defined as follows:

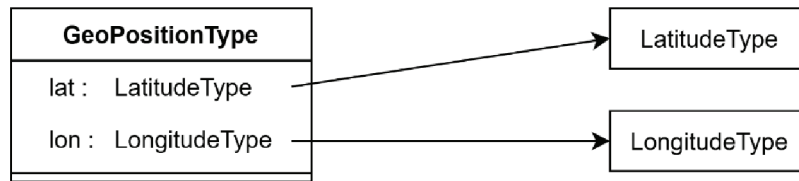
```

<complexType name="MRSceneType">
  <sequence>
    <element name="GeoOrigin" type="h:GeoPositionType"
      minOccurs="0" />
    <element name="GeoBoundingBox" type="h:GeoBoundingBoxType"
      minOccurs="0" />
    <element name="Orientation" type="h:OrientationType"
      minOccurs="0" />
    <element name="MRObjct" type="h:MRObjctType" minOccurs="0"
      maxOccurs="unbounded" />
    <element name="HumanObject" type="h:HumanObjectType"
      minOccurs="0" maxOccurs="unbounded" />
  </sequence>
</complexType>

```

7.4 GeoPositionType

The location of an MR scene is defined by a geo-origin and geo-bounding box. GeoPositionType includes information about the latitude and longitude of the MR scene. The following shows the composition of the geo-position of an MR scene:



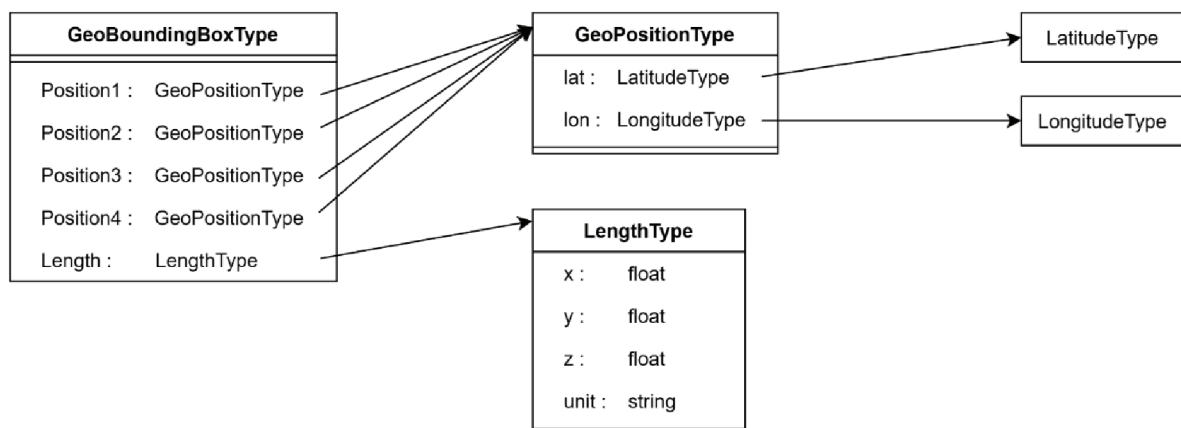
The XML schema for the geo-position is defined as follows:

```

<complexType name="GeoPositionType">
  <attribute type="h:LatitudeType" name="lat" use="required" />
  <attribute type="h:LongitudeType" name="lon" use="required" />
</complexType>
<simpleType name="LatitudeType">
  <restriction base="decimal">
    <minInclusive value="-90.0" />
    <maxInclusive value="90.0" />
  </restriction>
</simpleType>
<simpleType name="LongitudeType">
  <restriction base="decimal">
    <minInclusive value="-180.0" />
    <maxInclusive value="180.0" />
  </restriction>
</simpleType>
  
```

7.5 GeoBoundingBoxType

An MR scene for a Virtual smart city should be located in a virtual environment so the scene represents the real environment in a seamless way. To match the MR scene with its corresponding real environment, it is necessary to define a bounding box based on the geo-origin. ISO/IEC 18038 describes a method to define a 3D space for the MR scene. GeoBoundingBoxType is defined by four geo-positions and length elements. The following diagram shows the composition of a geo-bounding box for an MR scene.



The XML schema for the geo-bounding box is defined as follows:

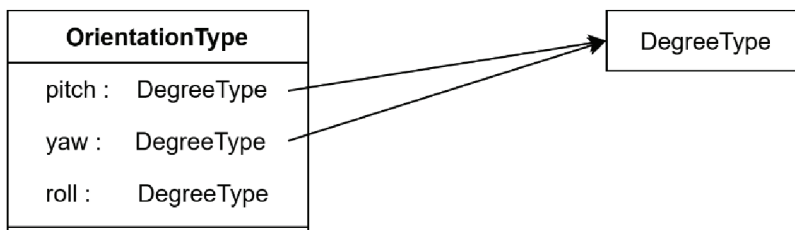
```

<complexType name="GeoBoundingBoxType">
  <sequence>
    <element name="Position1" type="h:GeoPositionType" />
    <element name="Position2" type="h:GeoPositionType" />
    <element name="Position3" type="h:GeoPositionType" />
    <element name="Position4" type="h:GeoPositionType" />
    <element name="Length" type="h:LengthType" />
  </sequence>
</complexType>
<complexType name="LengthType">
  <attribute name="x" type="float" use="required" />
  <attribute name="y" type="float" use="required" />
  <attribute name="z" type="float" use="required" />
  <attribute name="unit" type="string" default="m" />
</complexType>

```

7.6 OrientationType

An MR scene should be able to be located in a virtual environment with orientation information. OrientationType consists of pitch, yaw, and roll elements. The following diagram shows the composition of orientation information:



The XML schema for the orientation information is defined as follows:

```

<complexType name="OrientationType">
  <attribute name="pitch" type="h:DegreeType" use="required" />
  <attribute name="yaw" type="h:DegreeType" use="required" />
  <attribute name="roll" type="h:DegreeType" use="required" />
</complexType>
<simpleType name="DegreeType">
  <restriction base="decimal">
    <minInclusive value="0.0" />
    <maxInclusive value="360.0" />
  </restriction>
</simpleType>

```

7.7 MR ObjectType

MRObjecType is defined by name, shape, physical property, and physical sensor. The following diagram shows the composition of an MR object:

MRObjectType	
id :	ID
Name :	string
Shape :	ShapeType
PhysicalProperty :	PhysicalPropertyType
PhysicalSensor :	SensorType

The XML schema for the MR object is defined as follows:

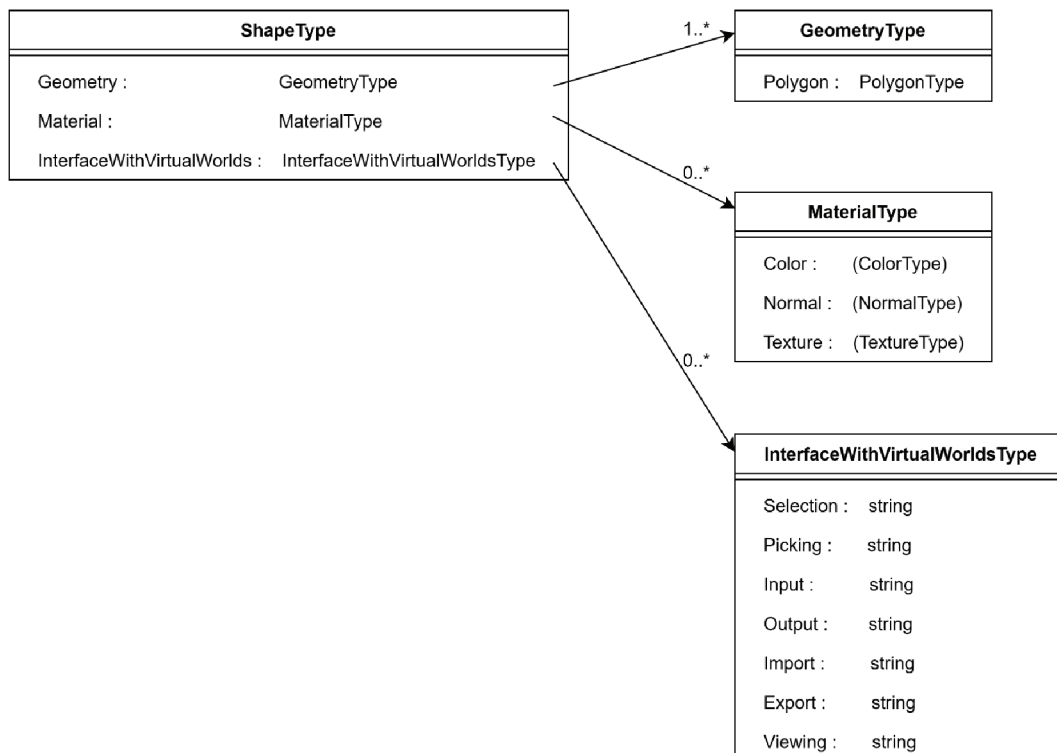
```

<complexType name="MRObjectType">
  <sequence>
    <element name="Name" type="string" />
    <element name="Shape" type="h:ShapeType" minOccurs="0" />
    <element name="PhysicalProperty" type="h:PhysicalPropertyType"
      minOccurs="0" />
    <element name="PhysicalSensor" type="h:SensorType"
      maxOccurs="unbounded" minOccurs="0" />
  </sequence>
  <attribute name="id" type="ID" use="required" />
</complexType>

```

7.8 ShapeType

ShapeType defines the shape information of a 3D object which consists of geometry, material, and interface with an MR object.



The XML schema of the shape type is defined as follows:

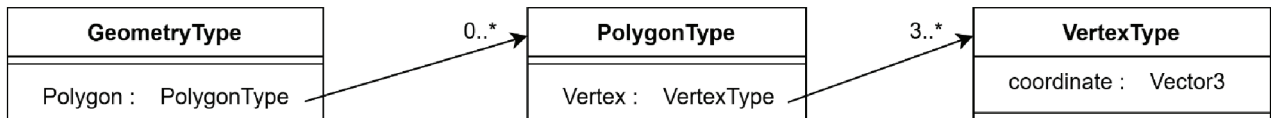
```

<complexType name="ShapeType">
  <sequence>
    <element name="Geometry" type="mar:GeometryType"
      maxOccurs="unbounded" minOccurs="0" />
    <element name="Material" type="mar:MaterialType"
      maxOccurs="unbounded" minOccurs="0" />
    <element name="InterfaceWithVirtualWorlds"
      type="mar:InterfaceWithVirtualWorldsType"
      maxOccurs="unbounded" minOccurs="0" />
  </sequence>
</complexType>

```

7.9 GeometryType

GeometryType for the shape type consists of polygon sets while each polygon has vertices. The following diagram shows the composition of the geometry type.



The XML schema of the geometry type is defined as follows:

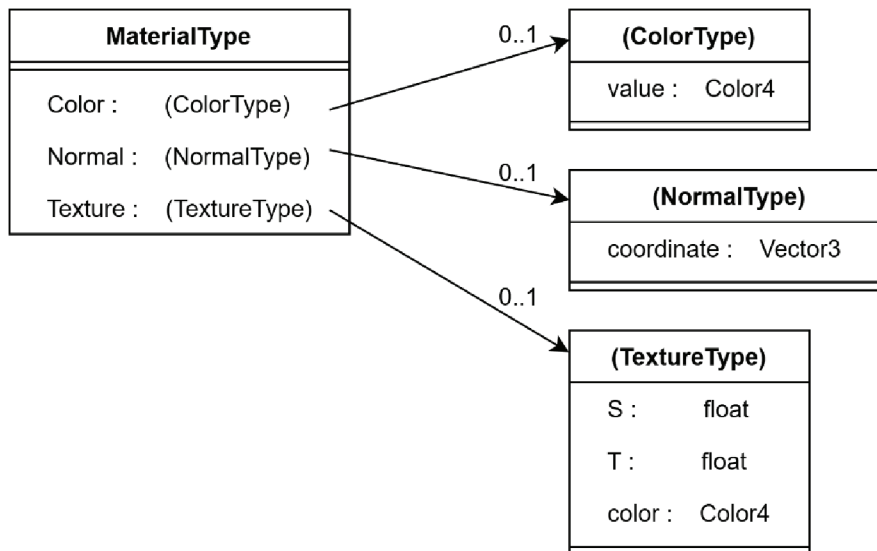
```

<complexType name="GeometryType">
  <choice maxOccurs="unbounded" minOccurs="0">
    <element name="Polygon" type="mar:PolygonType" />
  </choice>
</complexType>
<complexType name="PolygonType">
  <sequence>
    <element name="Vertex" type="mar:VertexType"
      maxOccurs="unbounded"/>
  </sequence>
</complexType>
<complexType name="VertexType">
  <attribute name="coordinate" type="mar:Vector3"/>
</complexType>

```

7.10 MaterialType

MaterialType for the shape type consists of color, normal, and texture information. The following diagram shows the composition of the material type.



The XML schema of the material type is defined as follows:

```

<complexType name="MaterialType">
  <sequence>
    <element name="Color" minOccurs="0">
      <complexType>
        <attribute name="value" type="mar:Color4"/>
      </complexType>
    </element>
    <element name="Normal" minOccurs="0">
      <complexType>
        <attribute name="coordinate" type="mar:Vector3"/>
      </complexType>
    </element>
    <element name="Texture" minOccurs="0">
      <complexType>
        <attribute name="S" type="float"/>
        <attribute name="T" type="float"/>
        <attribute name="color" type="mar:Color4" />
      </complexType>
    </element>
  </sequence>
</complexType>

```

7.11 InterfaceWithVirtualWorldsType

InterfaceWithVirtualWorlds defines the interface with virtual worlds type, which consists of selection, picking, input, output, import, export, and viewing controls. The following diagram shows the composition of the type.