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Information technology — Computer graphics, image processing and environmental data representation — Guidelines for representation and visualization of smart cities

Technologies de l'information — Infographie, traitement d'images et représentation de données environnementales — Lignes directrices relatives à la représentation et à la visualisation des villes intelligentes

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Foreword

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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 and www.iec.ch/national-committees.

Introduction

Developers and users of a smart city need tools to evaluate and examine options and trade-offs and predict outcomes. Parts or all of a smart city may need to be modelled, and smart city functions need to be simulated to evaluate possible outcomes. The modelling and simulation of smart city functions and processes require representation and visualization of the data. Representation and visualization of smart cities enable prototyping, demonstration and analysis of smart city concepts for further development. Both physical/geometric and semantic data can be represented and visualized. Representation and visualization of smart cities is a prime application for an integrated approach to leverage standardization since no single standard may address all requirements. This document provides guidance as to what needs to be represented for smart cities and how this can be achieved.

This document describes categories of data associated with smart cities and guidelines for their representation and visualization. It describes how standards can be applied to represent and visualize urban infrastructure, services and features. Use cases are presented that explore how these standards could be applied in smart city analysis and visualization applications.

Information technology — Computer graphics, image processing and environmental data representation — Guidelines for representation and visualization of smart cities

1 Scope

This document specifies guidelines for the representation and visualization of smart cities. This document:

a) describes the concepts of a smart city, smart city object and smart city data,

b) describes categories of data associated with smart cities,

c) provides guidance for representation of smart cities,

d) describes guidance for visualization of smart cities,

e) provides guidance in selecting the appropriate representation and visualization technique for different categories of smart city data using standards, and

f) provides use cases for applying standards to the representation and visualization of smart cities.

2 Normative references

There are no normative references in the document.

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

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

ISO and IEC maintain terminology 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/

3.1.1
3D city model
representation of an urban environment with a 3D geometry of typical or specific urban objects and structures, with buildings as the most prominent features

3.1.2
analytical data
data that has been derived from properties or applications of a smart city

Note 1 to entry: Examples of analytical data include data describing car traffic and pedestrian movements obtained from sensors.

3.1.3
big data
extensive datasets, primarily with characteristics of volume, variety, velocity and/or variability, that require a scalable technology for efficient storage, manipulation and analysis

Note 1 to entry: Big data is commonly used in many different ways, for example as the name of the scalable technology used to handle big data extensive datasets.

[SOURCE: ISO/IEC 20546:2019, 3.1.2]

3.1.4
built environment
human-made environment that includes buildings, roads, bridges, tunnels and city artefacts

3.1.5
Data Representation Model
DRM
standardized representation of the relationships and organization of environmental objects and content within SEDRIS

Note 1 to entry: SEDRIS refers to the ISO/IEC 18023 series.

3.1.6
Internet of Things
IoT
infrastructure of interconnected objects, people, systems and information resources together with intelligent services to allow them to process information of the physical and the virtual world and to react

[SOURCE: ISO/IEC 23093-1:2022, 3.2.9]

3.1.7
physical property
measurable quantity that describes the state of a system

Note 1 to entry: Physical properties can be categorized as mechanical, electrical, optical or thermal and may be scalar values (such as temperature) or vector quantities (such as wind flow).

3.1.8
presentation
organization of data into textual, tabular or graphical format

Note 1 to entry: This can include non-visual modes of presentation such as audio and haptics.

3.1.9
representation
description of a real-world event, system, behaviour or natural phenomenon

Note 1 to entry: In this document, representation refers to the digital description of an event, object or system.

3.1.10
semantic property
property that does not have a physical basis

Note 1 to entry: Building ownership is an example of a semantic property.

3.1.11
smart city
city that increases the pace at which it provides social, economic and environmental sustainability outcomes and responds to challenges such as climate change, rapid population growth, and political and economic instability by fundamentally improving how it engages society, applies collaborative leadership methods, works across disciplines and city systems, and uses data information and modern technologies to deliver better services and quality of life to those in the city (residents, businesses, visitors), now and for the foreseeable future, without unfair disadvantage of others or degradation of the natural environment

Note 1 to entry: A virtual smart city is its digital/simulated representation.

[SOURCE: ISO 37122:2019, 3.4, modified — The original Notes to entry have been deleted and replaced by a new Note to entry.]

3.1.12
smart city data
data that is associated with a smart city

Note 1 to entry: This refers to data that may be consumed or produced by a smart city function or application.

3.1.13
smart city object
representation of a distinct object that is part of a real or virtual smart city

Note 1 to entry: A smart city object may not necessarily contain smart technology. It is used as a general descriptor for a component of a smart city.

3.1.14
spatiotemporal
associated with both space and time

3.1.15
visualization
rendering of an object, situation or set of information as a chart or image

Note 1 to entry: Visualization is a subset of presentation restricted to the visual medium.

3.2 Abbreviated terms

2D	two dimensional
3D	three dimensional
API	application programming interface
AR	augmented reality
BIIF	basic image interchange format
BIM	building information modelling
CCTV	closed circuit television
DICOM	digital imaging and communications in medicine
DIS	distributed interactive simulation
DRM	data representation model
EDCS	environmental data coding specification

GIS	geographic information system
GKS	graphical kernel system
GPS	geospatial positioning system
HAnim	humanoid animation
ICT	information and communications technology
IoT	internet of things
JPEG	joint photographic experts group
JSON	JavaScript object notation
MAR	mixed and augmented reality
MPEG	moving picture experts group
OGC	open geospatial consortium
PHIGS	programmer's hierarchical interactive graphics system
PNG	portable network graphics
SEDRIS	synthetic environment data representation and interchange specification
SRM	spatial reference model
VR	virtual reality
VRML	virtual reality modeling language
X3D	extensible 3D
X3DOM	X3D document object model
XML	extensible markup language

4 Representation and visualization standards

4.1 Standards overview

ISO standards for imagery, environmental representation, visualization and mixed and augmented reality can be applied to smart cities. These are described in the following subsections.

4.2 Representation standards

The SEDRIS series (ISO/IEC 18023 series) provides a suite of standards for environmental representation. SEDRIS is an infrastructure technology that enables information technology applications to express, understand, share and reuse environmental data. SEDRIS technologies provide the means to represent integrated environmental data (terrain, ocean, air and space), and promote the unambiguous, loss-less and non-proprietary interchange of environmental data. It is a means of organising environmental and feature data, yet leaves the (graphical) presentation of that data to other applications, such as X3D[1)] and other visualization tools. SEDRIS was developed for military training simulation and has mainly been applied in that domain. An introduction to SEDRIS is provided in Reference [1].

1) X3D is a trademark of the Web3D Consortium. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO or IEC.

The components of SEDRIS are:

— functional specification (ISO/IEC 18023-1)

— abstract transmittal format (ISO/IEC 18023-2)

— transmittal format binary encoding (ISO/IEC 18023-3)

— SEDRIS language bindings – Part 4: C (ISO/IEC 18024-4)

— environmental data coding specification (EDCS) that provides identification (designation) of objects and their attributes (ISO/IEC 18025)

— spatial reference model (SRM) that handles position, orientation and spatial reference frames (ISO/IEC 18026)

— data representation model (DRM) that models the relationships between objects and their representations as described in ISO/IEC 18023 series

— application programming interface (API) as described in ISO/IEC 18023 series

EDCS, DRM and SRM all have ISO/IEC managed registries. The EDCS standard and its corresponding registry contain entries for environmental concepts, objects and attributes, with about 1 500 classifications (types of environmental objects) and 1 900 attributes. These entries include a wide range of environmental concepts, from natural phenomena to human-made objects, and a large array of attributes and units of measure. Many of the EDCS entries are relevant to smart city modelling and simulation, and new entries can be added through registration to ISO as these are required. Since SEDRIS was developed primarily for military environments, a considerable number of entries can be included to populate civilian urban environments.

SEDRIS is extensible through the ISO registration system for EDCS and SRM for new objects, features and coordinate systems. It includes Levels of Detail and georeferencing. While developed for military use SEDRIS can also represent civil assets and systems such as a smart city.

The HAnim standard[2,3] was developed for humanoid representation. HAnim supports a wide variety of articulated figures, including anatomically correct human models, incorporating haptic and kinematic interfaces to enable shareable skeletons, bodies and animations. HAnim extensions to facial animation and internal organs are under development.

4.3 Visualization standards

X3D and HAnim can be used for visualization of smart cities. X3D standards comprise three series: ISO/IEC 19775 (architecture), ISO/IEC 19776 (encodings), and ISO/IEC 19777 (language bindings). HAnim standards are ISO/IEC 19774-1 (architecture) and ISO/IEC 19774-2 (motion data animation).

X3D is a standard for 3D web graphics and is designed for viewing 3D content.[4] Existing models of cities, such as those using CityGML, can be converted to X3D for viewing on the web. X3D provides a system for the storage, retrieval and playback of 3D scenes within an open architecture to support a wide array of domains and user scenarios. It has componentized features that can be tailored for applications such as engineering and scientific visualization, medical visualization, training and simulation.

The most basic X3D part is a *node.* Typical nodes are box, colour and shape. X3D *components* are groups of nodes that perform similar operations. The shape component, for example, includes nodes for shape appearance, material, fill properties, line properties and two-sided material. *Profiles* are collections of components.

X3D has a variety of encodings, namely XML, VRML, Compressed Binary and also JSON[4] and has language bindings for C, C++, C#, JavaScript[2)], Python[3)] and Java[4)] consistent with app development for mobile devices.[5] X3D includes georeferencing, appearance, topology, fast rendering and its node/component/profile approach leads to extensibility. X3D v4 will use HTML5 while the JavaScript framework X3D document object model (X3DOM) removes the need for plugins and runs on any browser.

HAnim can also be considered as a visualization standard supported by X3D as described above.

Many graphics standards such as the graphical kernel system (GKS) ISO 7942 and the programmer's hierarchical interactive graphics system (PHIGS) ISO/IEC 9592 and ISO/IEC 9593 are supported as they are still in use although now obsolescent. The most relevant imagery standards that can be used for smart cities are:

— ISO/IEC 15948 portable network graphics (PNG): a raster graphics file format that is widely used on web browsers. It was first standardized in 2004.[6] PNG has advantages over other common graphics formats such as GIF and JPEG with wider ranges of transparency options and colour depths[6].

— ISO/IEC 12087-5 basic image interchange format (BIIF): a standard for image interchange used principally for military surveillance applications[7].

4.4 Mixed and augmented reality standards

MAR spans the spectrum from reality to virtuality. It combines real and virtual data for visualization, rendering and other uses. The MAR standards implicitly include both representation and visualization. Several mixed and augmented reality standards are emerging, including:

— sensor representation in MAR (ISO/IEC 18038)

— MAR reference model (ISO/IEC 18039)

— live actor and entity representation in MAR (ISO/IEC 18040)

— information model for MAR content (ISO/IEC 3721-1)

The MAR reference model (ISO/IEC 18039) defines the scope and concepts for representing mixed and augmented reality, and provides a general system architecture for MAR applications, components, systems, services and specifications. However, it does not specify how a particular MAR application should be designed, developed or implemented, nor does it specify MAR implementation bindings to programming languages.

For a virtual smart city, ISO/IEC 18040 can be applied to include human interaction. A human could be immersed into a computer representation of a city.

For a real smart city, MAR standards such as the reference model and information model, combined with the use of SEDRIS and X3D standards, could assist a resident with many tasks such as navigation, points of interest (for example, restaurant locations and menus) selection, traffic warnings and shopping through apps on smart phones.

2) JavaScript is a registered trademark of Oracle Corporation. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO or IEC.

3) Python is a registered trademark of the Python Software Foundation. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO or IEC.

4) Java is a registered trademark of Oracle Corporation. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO or IEC.

5 Concepts

5.1 Overview

A smart city exploits modern information and communication technology (ICT) capabilities to provide greater efficiencies for urban areas. The smart city concept integrates ICT and various physical devices that can be connected to the Internet of Things (IoT) to optimize the efficiency of city operations and services and connect to citizens. Smart city technology allows city officials to interact directly with both community and city infrastructure to monitor city activities.

Some smart city concepts are illustrated in Figure 1. The illustration shows smart city concepts such as smart energy management, smart industry, smart government, smart office, smart traffic management and parking, smart health and smart buildings. Vast amounts of data can be streamed from devices embedded in a smart city, such as cameras, wearable health and fitness devices, environmental sensors and smartphones. Some of this data can be processed and visualized in near real time to aid decision makers for immediate action. This is an example of big data that requires specialised analysis tools to process it.

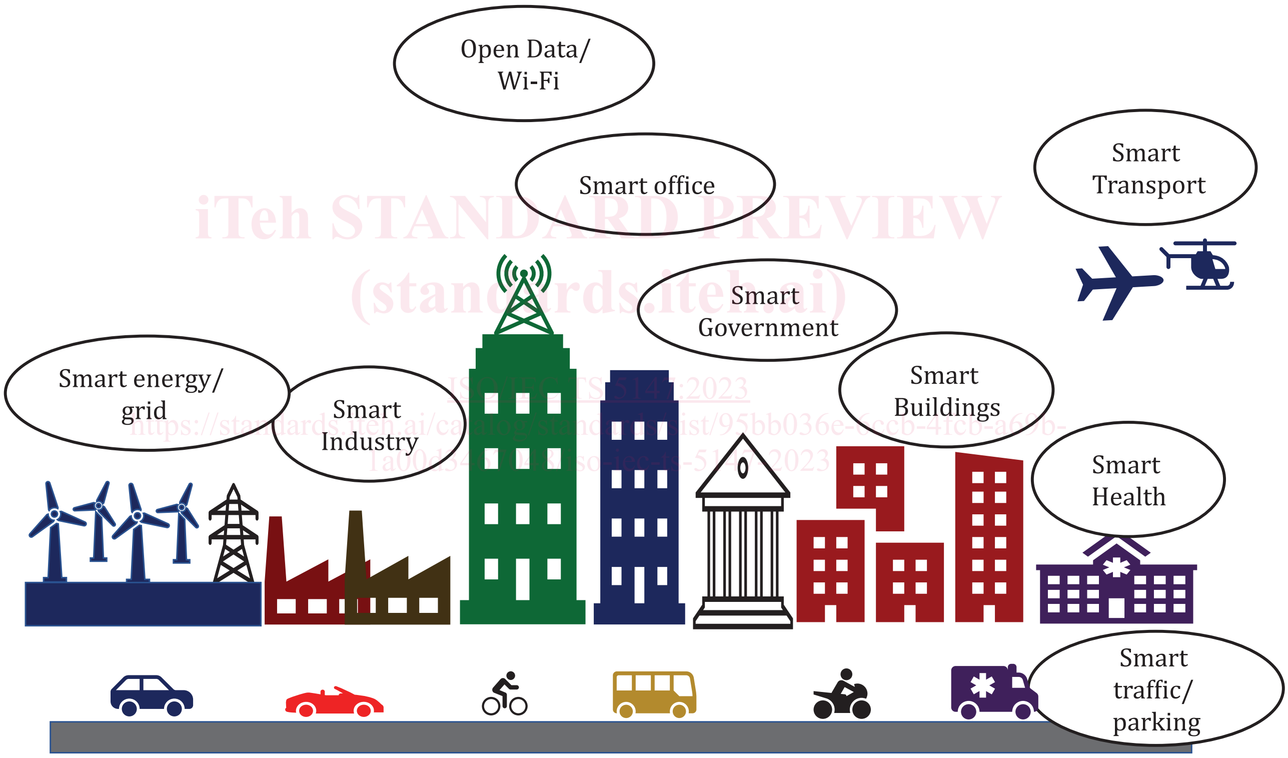

Figure 1 — Smart city concepts

5.2 Modelling, representing and visualizing smart cities

Developers and users of any smart city need tools to evaluate and examine options and predict outcomes. Parts or all of a smart city may need to be modelled and smart city functions need to be simulated to evaluate possible results. Such models and simulations may also need to be networked to produce larger integrated models and simulations. In addition, models and simulations developed during the design phase may be reused/repurposed during the execution and operation phases.

A smart city collects vast amounts of data through its sensor systems. These data can include weather readings (temperature, pressure, humidity, precipitation), environmental readings such as air quality, transport features and parking availability, energy consumption and waste management, solar irradiance, utility data related to buildings, measures for pedestrian levels and crowd behaviour, commercial data (such as financial transaction data) and likely air traffic control data for drones and

