SLOVENSKI STANDARD
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Geografske informacije - Modeli zaznavanja podob za geopozicioniranje - 2. del: SAR, InSAR, lidar in sonar

Geographic information -- Imagery sensor models for geopositioning -- Part 2: SAR, InSAR, lidar and sonar

Information géographique -- Modèles de capteurs d'images de géopositionnement -- Partie 2: SAR, InSAR, lidar et sonar

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TECHNICAL SPECIFICATION

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Geographic information — Imagery sensor models for geopositioning —

Part 2: SAR, InSAR, lidar and sonar

Information géographique — Modèles de capteurs d'images de géopositionnement —

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Foreword

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The committee responsible for this document is ISO/TC ISO/TC 211, *Geographic information/Geomatics*.

ISO/TS 19130 consists of the following parts, under the general title *Geographic information — Imagery sensor models for geopositioning*:

— *Geographic information — Imagery sensor models for geopositioning*

— *Part 2: Geographic information — Imagery sensor models for geopositioning — Part 2: SAR, InSAR, lidar and sonar*

Introduction

The purpose of this Technical Specification is to specify the geolocation information that an imagery data provider shall supply in order for the user to be able to find the earth location of the data using a detailed physical sensor model for Synthetic Aperture Radar (SAR), Light Detection And Ranging (lidar) and Sound Navigation And Ranging (sonar). The intent is to standardize sensor descriptions and specify the minimum geolocation metadata requirements for data providers and geopositioning imagery systems. Observations in this document are the generic meaning of the word; observations are not in the meaning of ISO 19156 observations.

Vast amounts of data from imaging systems have been collected, processed and distributed by government mapping and remote sensing agencies and by commercial data vendors. In order for this data to be useful in extraction of geographic information, further processing of the data are needed. Geopositioning, which determines the ground coordinates of an object from image coordinates, is a fundamental processing step. Because of the diversity of sensor types and the lack of a common sensor model standard, data from different producers may contain different parametric information, lack parameters required to describe the sensor that produces the data, or lack ancillary information necessary for geopositioning and analysing the data. Often, a separate software package must be developed to deal with data from each individual sensor or data producer. Standard sensor models and geolocation metadata allow agencies or vendors to develop generalized software products that are applicable to data from multiple data producers or from multiple sensors. With such standards, different producers can describe the geolocation information of their data in the same way, thus promoting interoperability of data between application systems and facilitating data exchange.

Part 1 provided a location model and metadata relevant to all sensors. It also included metadata specific to whiskbroom, pushbroom, and frame sensors, and some metadata for Synthetic Aperture Radar (SAR) sensors. In addition, it provided metadata for functional fit geopositioning, whether the function was part of a correspondence model or a true replacement model. It also provided a schema for these metadata elements. Comments on Part 1 stated that metadata needed to be specified for additional sensors. The technology of such sensors has now become sufficiently mature that standardization is now possible. This Technical Specification extends the specification of the set of metadata elements required for geolocation by providing physical sensor models for LIght Detection And Ranging (lidar) and SOund Navigation And Ranging (sonar), and it presents a more detailed set of elements for SAR. This Technical Specification also defines the metadata needed for the aerial triangulation of airborne and spaceborne images. This Technical Specification also provides a schema for all of these metadata elements.

Geographic information — Imagery sensor models for geopositioning —

Part 2:
SAR, InSAR, lidar and sonar

1 Scope

This Technical Specification supports exploitation of remotely sensed images. It specifies the sensor models and metadata for geopositioning images remotely sensed by Synthetic Aperture Radar (SAR), Interferometric Synthetic Aperture Radar (InSAR), LIght Detection And Ranging (lidar), and SOund Navigation And Ranging (sonar) sensors. The specification also defines the metadata needed for the aerial triangulation of airborne and spaceborne images.

This Technical Specification specifies the detailed information that shall be provided for a sensor description of SAR, InSAR, lidar and sonar sensors with the associated physical and geometric information necessary to rigorously construct a Physical Sensor Model. For the case where precise geoposition information is needed, this Technical Specification identifies the mathematical formulae for rigorously constructing Physical Sensor Models that relate two-dimensional image space to three-dimensional ground space and the calculation of the associated propagated error.

This Technical Specification does not specify either how users derive geoposition data or the format or content of the data the users generate.

2 Conformance

This Technical Specification specifies 5 conformance classes. There is one conformance class for each type of sensor. Any set of geopositioning information claiming conformance to this Technical Specification shall satisfy the requirements for at least one conformance class as specified in Table 1. The requirements for each class are shown by the presence of an X in the boxes for all clauses in the application test suite (ATS) required for that class. If the requirement is conditional, the box contains a C. The conditions are defined in the corresponding UML models.

Table 1 — Conformance classes

		Section of this part of ISO 19130							
		A.1.1	A.1.2	A.1.3	A.2	A.3	A.4	A.5	A.6
Conformance Class	SAR	X	C		X				
	InSAR	X	C			X			
	Lidar	X	X	X			X		
	Sonar	X	X	X				X	
	Aerial triangulation	X	C						X

3 Normative references

The following referenced documents are indispensable for the application 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/TS 19103:2005, *Geographic information — Conceptual schema language*

ISO 19107:2003, *Geographic information — Spatial schema*

ISO 19108:2002, *Geographic information — Temporal schema*

ISO 19111:2007, *Geographic information — Spatial referencing by coordinates*

ISO 19115-1:2014, *Geographic information — Metadata — Part 1: Fundamentals*

ISO 19115-2:2009, *Geographic information — Metadata — Part 2: Extensions for imagery and gridded data*

ISO 19123:2005, *Geographic information — Schema for coverage geometry and functions*

ISO 19157:2013, *Geographic information — Data quality*

ISO/TS 19130:2010, *Geographic information — Imagery sensor models for geopositioning*

4 Terms and definitions

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

4.1
active sensor
sensor (4.66) that generates the energy that it uses to perform the sensing

4.2
active sonar
type of *active sensor* (4.1) that transmits sound waves into the water and receives the returned waves echoed from objects in the water

4.3
adjustable model parameters
model parameters that can be refined using available additional information, such as ground control points, to improve or enhance modeling corrections

[SOURCE: ISO/TS 19130:2010, 4.2]

4.4
ARP
aperture reference point
3D location of the centre of the synthetic aperture

Note 1 to entry: It is usually expressed in ECEF coordinates in metres.

[SOURCE: ISO/TS 19130:2010, 4.4]

4.5
area recording
instantaneously recording an image in a single *frame* (4.22)

4.6
attitude
orientation of a body, described by the angles between the axes of that body's coordinate system and the axes of an external coordinate system

[SOURCE: ISO 19116:2004, 4.2]

4.7
attribute
named property of an entity

[SOURCE: ISO/IEC 2382-17:1999, 17.02.12]

4.8
azimuth resolution
<SAR> *resolution* (4.60) in the cross-range direction

Note 1 to entry: This is usually measured in terms of the impulse response of the SAR *sensor* (4.66) and processing system. It is a function of the size of the synthetic aperture, or alternatively the dwell time (e.g. larger aperture -> longer dwell time - > better resolution).

[SOURCE: ISO/TS 19130:2010, 4.7]

4.9
beam width
<SAR> useful angular width of the beam of electromagnetic energy

Note 1 to entry: For SAR, beam width is usually measured in radians and is the angular width between two points that have 1/2 of the power (3 dB below) of the centre of the beam. It is a property of the antenna. Power emitted outside of this angle is too little to provide a usable *return* (4.62).

Note 2 to entry: Angle, measured in a horizontal plane, between the directions on either side of the axis at which the *intensity* (4.37) of a beam of energy drops to a specified fraction of the value it has on the axis.

[SOURCE: ISO/TS 19130:2010, 4.8, modified — Notes 1 and 2 have been added.]

4.10
broadside
<SAR> direction orthogonal to the *velocity vector* (4.81) and parallel to the plane tangent to the Earth's ellipsoid at the nadir point of the *ARP* (4.4)

[SOURCE: ISO/TS 19130:2010, 4.9]

4.11
complex image
first-level product produced by processing SAR *Phase History Data* (4.48)

4.12
datum
parameter or set of parameters that define the position of the origin, the scale, and the orientation of a coordinate system

[SOURCE: ISO 19111:2007, 4.14]

4.13
depression angle
vertical angle from the platform horizontal plane to the *slant range direction* (4.56), usually measured at the *ARP* (4.4)

Note 1 to entry: Approximately the complement of the *look angle* (4.42).

4.14
Differential Global Navigational Satellite System
enhancement to Global Positioning System that uses GNSS and DGNSS to broadcast the difference between the positions indicated by the satellite systems and the known fixed positions

4.15
Doppler angle
<SAR> angle between the *velocity vector* (4.81) and the *range vector* (4.58)

[SOURCE: ISO/TS 19130:2010, 4.19]

4.16
Doppler shift
wavelength change resulting from relative motion of source and detector

Note 1 to entry: In the SAR context, it is the frequency shift imposed on a radar signal due to relative motion between the *transmitter* (4.79) and the object being illuminated.

[SOURCE: ISO/TS 19130:2010, 4.20]

4.17
draught
vertical distance, at any section of a vessel from the surface of the water to the bottom of the keel

[SOURCE: IHO Hydrographic Dictionary, S-32, Fifth Edition]

4.18
easting
E
distance in a coordinate system, eastwards (positive) or westwards (negative) from a north-south reference line

[SOURCE: ISO 19111:2007, 4.16]

4.19
field of regard
total angular extent over which the *field of view (FOV)* (4.20) may be positioned

Note 1 to entry: The field of regard is the area that is potentially able to be viewed by a system at an instant in time. It is determined by the system's FOV and the *range* (4.54) of directions in which the system is able to point.

[SOURCE: Adapted from the Manual of Photogrammetry]

4.20
field of view
FOV
instantaneous region seen by a *sensor* (4.66), provided in angular measure

Note 1 to entry: In the airborne case, this would be *swath* (4.75) width for a linear array, ground footprint for an area array, and for a whiskbroom scanner it refers to the swath width.

[SOURCE: Manual of Photogrammetry]

4.21
first return
first reflected signal that is detected by a 3D imaging system, time of flight (TOF) type, for a given sampling position and a given emitted pulse

[SOURCE: Adapted from STM E2544]

4.22
frame
<lidar> data collected by the *receiver* (4.59) as a result of all *returns* (4.62) from a single emitted pulse

Note 1 to entry: A complete 3D data sample of the world produced by a *lidar* (4.40) taken at a certain time, place, and orientation. A single lidar frame is also referred to as a *range* (4.54) image.

[SOURCE: Adapted from NISTIR 7117]

4.23
geiger mode
photon counting mode for *lidar* (4.40) systems, where the detector is biased and becomes sensitive to individual photons

Note 1 to entry: These detectors exist in the form of arrays and are bonded with electronic circuitry. The electronic circuitry produces a measurement corresponding to the time at which the current was generated; resulting in a direct time-of-flight measurement. A lidar that employs this detector technology typically illuminates a large scene with a single pulse. The direct time-of-flight measurements are then combined with platform location/*attitude* (4.6) data along with pointing information to produce a three-dimensional product of the illuminated scene of interest. Additional processing is applied which removes existing noise present in the data to produce a visually exploitable data set.

[SOURCE: Adapted from Albota 2002]

4.24
geodetic coordinate system
coordinate system in which position is specified by geodetic latitude, geodetic longitude and (in the three-dimensional case) ellipsoidal height

[SOURCE: ISO 19111:2007, 4.18]

4.25
geodetic datum
datum (4.12) describing the relationship of a two- or three-dimensional coordinate system to the Earth

Note 1 to entry: In most cases, the geodetic datum includes an ellipsoid description (ISO/TS 19130:2010)

Note 2 to entry: The term and this Technical Specification may be applicable to some other celestial bodies.

[SOURCE: ISO 19111:2007, 4.24, modified — Notes 1 and 2 have been added.]

4.26
geographic coordinates
longitude, latitude and height of a ground or elevated point

Note 1 to entry: Geographic coordinates are related to a coordinate reference system or compound coordinate reference system. Depth equals negative height.

4.27
geographic information
information concerning phenomena implicitly or explicitly associated with a location relative to the Earth

[SOURCE: ISO 19101:2002, 4.16]

4.28
geolocating
geopositioning an object using a Physical *Sensor Model* (4.68) or a True Replacement Model

[SOURCE: ISO/TS 19130:2010, 4.34]

4.29
grazing angle
<SAR> vertical angle from the local surface tangent plane to the *slant range direction* (4.56)

Note 1 to entry: It is usually measured at the GRP and approximately the complement of the *incident angle* (4.35)

[SOURCE: ISO/TS 19130:2010, 4.39, modified — Note 1 to entry has been added.]

4.30
hydrophone
<sonar> component of the sonar system which receives the sound echo and converts it to an electric signal

4.31
heave
oscillatory rise and fall of a ship due to the entire hull being lifted by the force of the sea

[SOURCE: IHO Hydrographic Dictionary S-32, Fifth Edition]

4.32
hydrographic swath
<sonar> strip or lane on the ground scanned by a multi-beam sounder when the survey vessel proceeds along its course

[SOURCE: IHO Hydrographic Dictionary S-32, Fifth Edition]

4.33
image coordinates
coordinates with respect to a Cartesian coordinate system of an image

Note 1 to entry: The image coordinates can be in pixels or in a measure of length (linear measure).

4.34
image formation
<SAR> process by which an image is generated from collected *Phase History Data* (4.48) in a SAR system

[SOURCE: ISO/TS 19130:2010, 4.51]

4.35
incident angle
vertical angle between the line from the detected element to the *sensor* (4.66) and the local surface normal (tangent plane normal)

Note 1 to entry: It is approximately the complement of the *grazing angle* (4.29).

[SOURCE: ISO/TS 19130:2010, 4.57, modified — Note 1 to entry has been added.]

4.36
instantaneous field of view
instantaneous region seen by a single detector element, measured in angular space

[SOURCE: Manual of Photogrammetry]

4.37
intensity
power per unit solid angle from a point source into a particular direction

Note 1 to entry: Typically for *lidar* (4.40), sufficient calibration has not been done to calculate absolute intensity, so relative intensity is usually reported. In *linear mode* (4.41) systems, this value is typically provided as an integer, resulting from a mapping of the *return's* (4.62) signal power to an integer value via a lookup table.

4.38
last return
last reflected signal that is detected by a 3D imaging system, time-of-flight (TOF) type, for a given sampling position and a given emitted pulse

[SOURCE: Adapted from ASTM E2544]

4.39
layover
visual effect in SAR images of ambiguity among *returns* (4.62) from scatterers at different heights that fall into the same range-Doppler-time bin

Note 1 to entry: The effect makes buildings "lay over" onto the ground toward the *sensor* (4.66)*velocity vector* (4.81), akin to perspective views in projective imagery.

4.40
lidar
light detection and ranging
system consisting of 1) a photon source (frequently, but not necessarily, a laser), 2) a photon detection system, 3) a timing circuit, and 4) optics for both the source and the *receiver* (4.59) that uses emitted laser light to measure *ranges* (4.54) to and/or properties of solid objects, gases, or particulates in the atmosphere

Note 1 to entry: Time of flight (TOF) lidars use short laser pulses and precisely record the time each laser pulse was emitted and the time each reflected *return(s)* (4.62) is received in order to calculate the distance(s) to the scatterer(s) encountered by the emitted pulse. For *topographic lidar* (4.80), these time-of-flight measurements are then combined with precise platform location/*attitude* (4.6) data along with pointing data to produce a three-dimensional product of the illuminated scene of interest.

4.41
linear mode
lidar (4.40) system in which output photocurrent is proportional to the input optical incident *intensity* (4.37)

Note 1 to entry: A lidar system which employs this technology typically uses processing techniques to develop the time-of-flight measurements from the full waveform that is reflected from the targets in the illuminated scene of interest. These time-of-flight measurements are then combined with precise platform location/*attitude* (4.6) data along with pointing data to produce a three-dimensional product of the illuminated scene of interest.

[SOURCE: Adapted from Aull et al., 2002]

4.42
look angle
vertical angle from the *platform down direction* (4.50) to the *slant range direction* (4.56), usually measured at the *ARP* (4.4)

Note 1 to entry: It is approximately the complement of the *depression angle* (4.13).

4.43
mean sea level
MSL
average height of the surface of the sea at a tide station for all stages of the tide over a 19-year period, usually determined from hourly height readings measured from a fixed predetermined reference level

[SOURCE: IHO Hydrographic Dictionary S-32, Fifth Edition]

4.44
multibeam sonar
wide *swath* (4.75) echo sounder for use in seabed mapping and surveying using the multi-beam principle

Note 1 to entry: Depths are measured directly below and transverse to the ship's track. The width of the swath is a function of the number of beams and their aperture.

[SOURCE: IHO Hydrographic Dictionary S-32, Fifth Edition]