SLOVENSKI STANDARD
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Geografske informacije - Kalibracija in validacija oddaljenih posnetkov senzorjev zaznavanja in podatkov - 2. del: Lidar

Geographic information -- Calibration and validation of remote sensing imagery sensors and data -- Part 2: Lidar

Information géographique Calibration et validation de capteurs de télédétection -- Partie 2: Lidar

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Geographic information — Calibration and validation of remote sensing imagery sensors and data —

Part 2: Lidar

Information géographique – Calibration et validation de capteurs de télédétection —

Partie 2: Lidar

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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 ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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

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

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

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

ISO/TS 19159 consists of the following parts, under the general title *Geographic information — Calibration and validation of remote sensing imagery sensors and data*:

— Part 1: *Optical sensors* [Technical Specification]

— Part 2: *Lidar* [Technical Specification]

The following parts are planned:

— Part 3: *SAR/InSAR*

— Part 4: *SONAR*

Introduction

Imaging sensors are one of the major data sources for geographic information. The image data capture spatial and spectral measurements are applied for numerous applications ranging from road/town planning to geological mapping. Typical spatial outcomes of the production process are vector maps, Digital Elevation Models, and 3-dimensional city models. There are typically two streams of spectral analysis data, i.e. the statistical method, which includes image segmentation and the physics-based method which relies on characterisation of specific spectral absorption features.

In each of the cases the quality of the end products fully depends on the quality of the measuring instruments that has originally sensed the data. The quality of measuring instruments is determined and documented by calibration.

A calibration is often a costly and time consuming process. Therefore, a number of different strategies are in place that combine longer time intervals between subsequent calibrations with simplified intermediate calibration procedures that bridge the time gap and still guarantee a traceable level of quality. Those intermediate calibrations are called validations in this part of ISO/TS 19159.

The ISO 19159 series standardizes the calibration of remote sensing imagery sensors and the validation of the calibration information and procedures. It does not address the validation of the data and the derived products.

Many types of imagery sensors exist for remote sensing tasks. Apart from the different technologies the need for a standardization of the various sensor types has different levels of priority. In order to meet those requirements, the ISO 19159 series has been split into more than one part.

This part of ISO/TS 19159 covers the airborne land lidar sensor (light detection and ranging). It includes the data capture and the calibration. The result of a lidar data capture is a lidar cloud according to the ISO 19156:2011. The bathymetric lidar is not included in the ISO 19159 series.

ISO 19159-3 and ISO 19159-4 are planned to cover RADAR (Radio detection and ranging) with the subtopics SAR (Synthetic Aperture RADAR) and InSAR (Interferometric SAR) as well as SONAR (Sound detection and ranging) that is applied in hydrography.

Geographic information — Calibration and validation of remote sensing imagery sensors and data —

Part 2: Lidar

1 Scope

This part of ISO/TS 19159 defines the data capture method, the relationships between the coordinate reference systems and their parameters, as well as the calibration of airborne lidar (light detection and ranging) sensors.

This part of ISO/TS 19159 also standardizes the service metadata for the data capture method, the relationships between the coordinate reference systems and their parameters and the calibration procedures of airborne lidar systems as well as the associated data types and code lists that have not been defined in other ISO geographic information international standards.

2 Conformance

This part of ISO/TS 19159 standardizes the metadata for the data recording and the calibration procedures of airborne lidar systems as well as the associated data types and code lists. Therefore conformance depends on the type of entity declaring conformance.

Mechanisms for the transfer of data are conformant to this part of ISO/TS 19159 if they can be considered to consist of transfer record and type definitions that implement or extend a consistent subset of the object types described within this part of ISO/TS 19159.

Details of the conformance classes are given in the Abstract test suite in Annex A.

3 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

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

4 Terms and definitions

4.1
absolute accuracy
closeness of reported coordinate values to values accepted as or being true

Note 1 to entry: Absolute accuracy is stated with respect to a defined *datum* (4.11) or reference system.

Note 2 to entry: Absolute accuracy is also termed “external accuracy”.

4.2
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

Note 1 to entry: In photogrammetry, the attitude is the angular orientation of a camera (roll, pitch, yaw), or of the photograph taken with that camera, with respect to some external reference system. With *lidar* (4.19) and Interferometric Synthetic Aperature Radar (IFSAR), the attitude is normally defined as the roll, pitch and heading of the instrument at the instant an active pulse is emitted from the *sensor* (4.39).

[SOURCE: ISO 19116:2004, 4.2, modified — Note 1 to entry has been added.]

4.3
bare earth elevation
height (4.16) of the natural terrain free from vegetation as well as buildings and other man-made structures

4.4
boresight
calibration (4.6) of a *lidar* (4.19) *sensor* (4.36) system, equipped with an Inertial *Measurement* (4.20) Unit (IMU) and a Global Navigation Satellite System (GNSS), to accurately determine or establish its position and orientation

Note 1 to entry: The position of the lidar sensor system (x, y, z) is determined with respect to the GNSS antenna. The orientation (roll, pitch, heading) of the lidar sensor system is determined with respect to straight and level flight.

4.5
breakline
linear feature that describes a change in the smoothness or continuity of a surface

Note 1 to entry: A soft breakline ensures that known z-values along a linear feature are maintained (for example, elevations along a pipeline, road centreline or drainage ditch), and ensures that linear features and polygon edges are maintained in a *Triangulated Irregular Network (TIN)* (4.39) surface model, by enforcing the breaklines as TIN edges. They are generally synonymous with 3-D breaklines because they are depicted with series of x/y/z coordinates. Somewhat rounded ridges or the trough of a drain may be collected using soft breaklines.

Note 2 to entry: A hard breakline defines interruptions in surface smoothness, for example, to define streams, shorelines, dams, ridges, building footprints, and other locations with abrupt surface changes.

4.6
calibration
process of quantitatively defining a system's responses to known, controlled signal inputs

Note 1 to entry: A calibration is an operation that, under specified conditions, in a first step, establishes a relation between indications[with associated *measurement* (4.20) uncertainties] and the physical *quantity* (4.30) values (with measurement uncertainties) provided by measurement standards.

Note 2 to entry: Determining the systematic errors in a measuring device by comparing its measurements with the markings or measurements of a device that is considered correct. Airborne *sensors* (4.36) can be calibrated geometrically and radiometrically.

Note 3 to entry: An instrument calibration means the factory calibration includes radiometric and geometric calibration unique to each manufacturer's hardware and tuned to meet the performance specifications for the model being calibrated. Instrument calibration can only be assessed and corrected by the factory.

Note 4 to entry: The data calibration includes the lever-arm and *boresight* (4.4) calibration. It determines the sensor-to-GNSS-antenna offset vector (*lever arm*) (4.18) components relative to the antenna phase centre. The offset vector components are re-determined each time the sensor or aircraft GNSS antenna is moved or repositioned in any way. Because normal aircraft operations can induce slight variations in component mounting, field calibration is normally performed for each project, or even daily, to determine *corrections* (4.9) to the roll, pitch, yaw, instrument mounting alignment error and scale calibration parameters.

[SOURCE: ISO/TS 19101-2:2008, 4.2, modified — Notes 1 through 4 to entry have been added.]

4.7
calibration validation
process of assessing the validity of parameters

Note 1 to entry: With respect to the general definition of *validation* (4.41) the "dataset validation" only refers to a small set of parameters (attribute values) such as the result of a *sensor* (4.36) *calibration* (4.6).

[SOURCE: ISO/TS 19159-1:2014, 4.4]

4.8
check point
checkpoint
point in object space (ground) used to estimate the *positional accuracy* (4.29) of a geospatial dataset against an independent source of greater accuracy

4.9
correction
compensation for an estimated systematic effect

Note 1 to entry: See ISO/IEC Guide 98-3:2008, 3.2.3, for an explanation of 'systematic effect'.

Note 2 to entry: The compensation can take different forms, such as an addend or a factor, or can be deduced from a table.

[SOURCE: ISO/IEC Guide 99:2007, 2.53]

4.10
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]

4.11
digital elevation model
DEM
dataset of elevation values that are assigned algorithmically to 2-dimensional coordinates

[SOURCE: ISO/TS 19101-2:2008, 4.5]

4.12
digital surface model
DSM
digital elevation model (DEM) (4.11) that depicts the elevations of the top surfaces of buildings, trees, towers, and other features elevated above the bare earth

Note 1 to entry: DSMs are especially relevant for telecommunications management, air safety, forest management, and 3-D modelling and simulation.

4.13
digital terrain model
DTM
digital elevation model (DEM) (4.11) that incorporates the elevation of important topographic features on the land.

Note 1 to entry: DTMs are comprised of mass points and *breaklines* (4.5) that are irregularly spaced to better characterize the true shape of the bare-earth terrain. The net result of DTMs is that the distinctive terrain features are more clearly defined and precisely located, and contours generated from DTMs more closely approximate the real shape of the terrain.

4.14
field of view
FOV
instantaneous region seen by a *sensor* (4.36), provided in angular measure

Note 1 to entry: In the airborne case, this would be *swath* (4.38) width for a linear array, ground footprint for an area array, and for a whiskbroom scanner it refers to the swath width.

Note 2 to entry: To avoid confusion, a typical airborne *lidar* (4.19) sensor with a field of view of 30 degrees is commonly depicted as ±15 degrees on either side of *nadir* (4.26).

[SOURCE: ISO/TS 19130-2:2014, 4.20 modified, — Note 2 to entry has been added.]

4.15
geographic information system
information system dealing with information concerning phenomena associated with location relative to the Earth

[SOURCE: ISO 19101-1:2014, 4.1.20]

4.16
height
h, *H*
distance of a point from a chosen reference surface measured upward along a line perpendicular to that surface

Note 1 to entry: A height below the reference surface will have a negative value.

Note 2 to entry: The terms elevation and height are synonyms.

[SOURCE: ISO 19111:2007, 4.29, modified – Note 2 to entry have been added.]

4.17
horizontal accuracy
positional accuracy (4.29) of a dataset with respect to a horizontal *datum* (4.10)

4.18
lever arm
relative position vector of one *sensor* (4.36) with respect to another in a direct georeferencing system

Note 1 to entry: For example, with aerial mapping cameras, there are lever arms between the inertial centre of the Inertial *Measurement* (4.20) Unit (IMU) and the phase centre of the Global Navigation Satellite System (GNSS) antenna, each with respect to the camera perspective centre within the lens of the camera.

4.19
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 that uses emitted laser light to measure ranges 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) is received in order to calculate the distance(s) to the scatterer(s) encountered by the emitted pulse. For topographic lidar , these time-of-flight measurements are then combined with precise platform location/attitude data along with pointing data to produce a three dimensional product of the illuminated scene of interest.

[SOURCE: ISO/TS 19130-2:2014, 4.40]

4.20
measurement
set of operations having the object of determining the value of a *quantity* (4.30)

[SOURCE: ISO/TS 19101-2:2008, 4.20]

4.21
measurement accuracy
accuracy of measurement
accuracy
closeness of agreement between a test result or *measurement* (4.20) result and the true value

Note 1 to entry: The concept 'measurement accuracy' is not a *quantity* (4.30) and is not given a numerical *quantity* (4.30) value. A measurement is said to be more accurate when it offers a smaller *measurement error* (4.22).

Note 2 to entry: The term 'measurement accuracy' should not be used for measurement trueness and the term *measurement precision* (4.23) should not be used for 'measurement accuracy', which, however, is related to both these concepts.

Note 3 to entry: 'Measurement accuracy' is sometimes understood as closeness of agreement between measured quantity values that are being attributed to the measurand.

Note 4 to entry: In this part of ISO/TS 19159, the true value can be a reference value that is accepted as true.

Note 5 to entry: With the exception of Continuously Operating Reference Stations (CORS), assumed to be known with zero errors relative to established *datums* (4.10), the true locations of 3-D spatial coordinates of other points are not truly known, but only estimated; therefore, the accuracy of other coordinate information is unknown and can only be estimated.

Note 6 to entry: Accuracy is not a quantity and is not given a numerical quantity value.

[SOURCE: ISO 3534-2:2006, 3.3.1, modified, — Notes 1 through 6 to entry have been added.]

4.22
measurement error
error of measurement
error
measured *quantity* (4.30) value minus a reference quantity value

Note 1 to entry: The concept of 'measurement error' can be used both

a) when there is a single reference *quantity* (4.30) value to refer to, which occurs if a *calibration* (4.6) is made by means of a *measurement* (4.20) standard with a measured quantity value having a negligible measurement *uncertainty* (4.40) or if a conventional quantity value is given, in which case the measurement error is known, and

b) if a measurand is supposed to be represented by a unique true quantity value or a set of true quantity values of negligible range, in which case the measurement error is not known.

Note 2 to entry: Measurement error should not be confused with production error or mistake.

[SOURCE: ISO/IEC Guide 99:2007, 2.16]

4.23
measurement precision
precision
closeness of agreement between indications or measured *quantity* (4.30) values obtained by replicate *measurements* (4.20) on the same or similar objects under specified conditions

Note 1 to entry: Measurement precision is usually expressed numerically by measures of imprecision, such as standard deviation, variance, or coefficient of variation under the specified conditions of measurement.

Note 2 to entry: The 'specified conditions' can be, for example, repeatability conditions of measurement, intermediate precision conditions of measurement, or reproducibility conditions of measurement (see ISO 5725-3:1994).