TECHNICAL SPECIFICATION

ISO/TS 16610-41

First edition
2006-11-01

Geometrical product specifications (GPS) — Filtration —

Part 41:
Morphological profile filters: Disk and horizontal line-segment filters

Spécification géométrique des produits (GPS) — Filtrage —

Partie 41: Filtres de profil morphologiques: Filtre disque et filtre segment de droite horizontal

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

In other circumstances, particularly when there is an urgent market requirement for such documents, a technical committee may decide to publish other types of normative document:

— an ISO Publicly Available Specification (ISO/PAS) represents an agreement between technical experts in an ISO working group and is accepted for publication if it is approved by more than 50 % of the members of the parent committee casting a vote;

— an ISO Technical Specification (ISO/TS) represents an agreement between the members of a technical committee and is accepted for publication if it is approved by 2/3 of the members of the committee casting a vote.

An ISO/PAS or ISO/TS is reviewed after three years in order to decide whether it will be confirmed for a further three years, revised to become an International Standard, or withdrawn. If the ISO/PAS or ISO/TS is confirmed, it is reviewed again after a further three years, at which time it must either be transformed into an International Standard or be withdrawn.

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.

ISO/TS 16610-41 was prepared by Technical Committee ISO/TC 213, *Dimensional and geometrical product specifications and verification*.

ISO/TS 16610 consists of the following parts, under the general title *Geometrical product specifications (GPS) — Filtration*:

— *Part 1: Overview and basic concepts*

— *Part 20: Linear profile filters: Basic concepts*

— *Part 22: Linear profile filters: Spline filters*

— *Part 29: Linear profile filters: Spline wavelets*

— *Part 31: Robust profile filters: Gaussian regression filters*

— *Part 32: Robust profile filters: Spline filters*

— *Part 40: Morphological profile filters: Basic concepts*

— *Part 41: Morphological profile filters: Disk and horizontal line-segment filters*

— *Part 49: Morphological profile filters: Scale space techniques*

The following parts are under preparation:

— *Part 21: Linear profile filters: Gaussian filters*

— *Part 26: Linear profile filters: Filtration on nominally orthogonal grid planar data sets*

— *Part 27: Linear profile filters: Filtration on nominally orthogonal grid cylindrical data sets*

— *Part 30: Robust profile filters: Basic concepts*

— *Part 42: Morphological profile filters: Motif filters*

— *Part 60: Linear areal filters: Basic concepts*

— *Part 61: Linear areal filters: Gaussian filters*

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— *Part 69: Linear areal filters: Spline wavelets*

— *Part 70: Robust areal filters: Basic concepts*

— *Part 71: Robust areal filters: Gaussian regression filters*

— *Part 72: Robust areal filters: Spline filters*

— *Part 80: Morphological areal filters: Basic concepts*

— *Part 81: Morphological areal filters: Sphere and horizontal planar segment filters*

— *Part 82: Morphological areal filters: Motif filters*

— *Part 89: Morphological areal filters: Scale space techniques*

Introduction

This part of ISO/TS 16610 is a geometrical product specification (GPS) Technical Specification and is to be regarded as a global GPS Technical Specification (see ISO/TR 14638). It influences the chain links 3 and 5 of all chains of standards.

For more detailed information about the relation of this part of ISO/TS 16610 to the GPS matrix model, see Annex B.

This part of ISO/TS 16610 provides guidelines for computing profile morphological operations and filters with disk and horizontal segment structuring elements. It also describes techniques for applying morphological filters, including envelope filters, for open profiles.

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Geometrical product specifications (GPS) — Filtration —

Part 41:
Morphological profile filters: Disk and horizontal line-segment filters

1 Scope

This part of ISO/TS 16610 specifies techniques for computing morphological filters with disk and horizontal segment structuring elements, including envelope filters.

2 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 14660-1:1999, *Geometrical Product Specifications (GPS) — Geometrical features — Part 1: General terms and definitions*

ISO/TS 16610-1:2006, *Geometric product specifications (GPS) — Filtration — Part 1: Overview and basic concepts*

ISO/TS 16610-40:2006, *Geometric product specifications (GPS) — Filtration — Part 40: Morphological profile filters: Basic concepts*

3 Terms and definitions

For the purposes of this document, the terms and definition givens in ISO 14660-1, ISO/TS 16610-1 and ISO/TS 16610-40 apply.

4 Morphological filters

4.1 General

The morphological filters described in this part of ISO/TS 16610 are defined using Minkowski sums. There are two primary morphological operations (dilation and erosion) and two secondary morphological operations (opening and closing). The opening and closing operators are also called morphological filters. Any technique that can compute Minkowski addition and subtraction can be used to compute closing and opening morphological filters and the respective envelope filters. Computation of morphological filters can be greatly simplified if we deal with discrete morphological filters, which are described in the rest of this document. The main body of the document deals with general computational techniques; Annexes A and B deal with specific implementations of discrete morphological operations and filters for profiles.

A morphological filter conforming to this part of ISO/TS 16610 shall exhibit the characteristics described in 4.3, 4.4, 4.5, 4.6, 5.1, 5.2 and 5.3.

NOTE   The relationship of morphological profile filters: disk and horizontal line-segment filters to the filtration matrix model is given in Annex B.

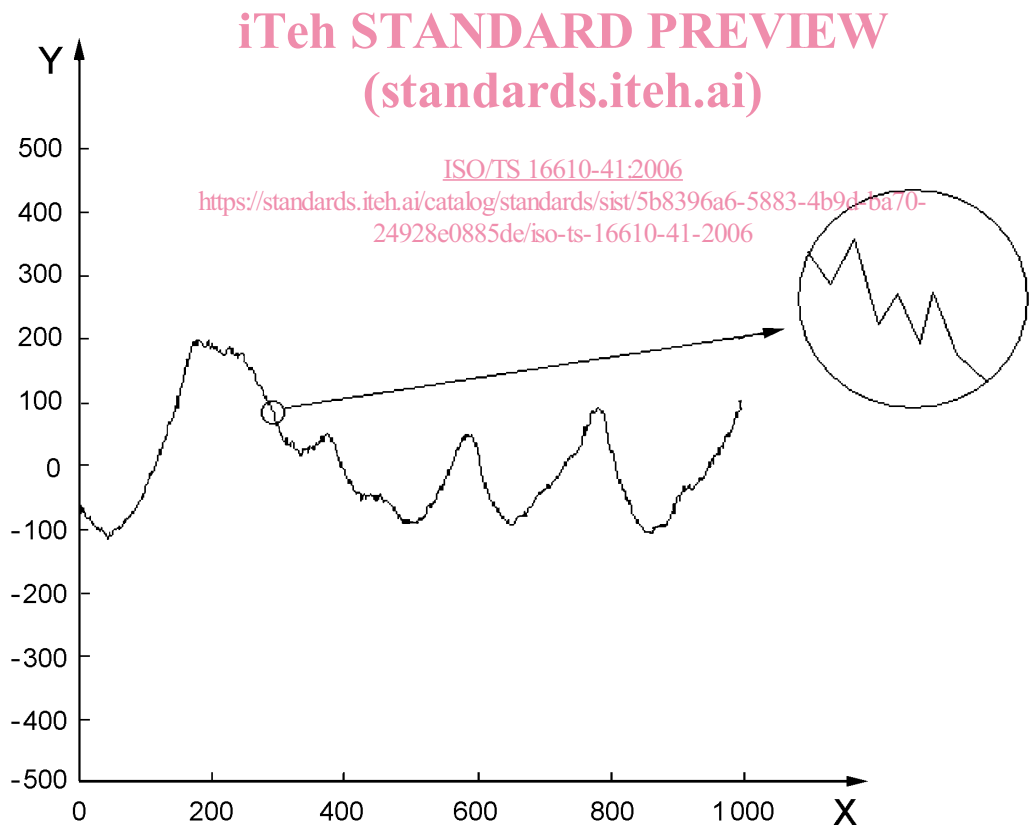## 4.2   Discrete representation of input data

An extracted profile is represented as a vector z of finite size n. This is a discrete representation a profile. For computational convenience, the sampling is assumed to be uniform with a sampling interval Δ. z_i, the ith component of z, is the value of the function evaluated at $i\Delta$.

EXAMPLE   The first five entries in a long input vector are given in z = [−63,3; −65,0; −67,0; −70,4; −69,6; …] where the dimensions are in μm. The interval Δ is 0,5 μm. The input vector can easily contain several thousand entries.

A continuous representation of the extracted profile can be obtained by an appropriate interpolation, e.g. a simple linear interpolation piece by piece of the discrete data. Figure 1 illustrates the graph of this kind of continuous representation, starting with a discrete representation using vector z.

4.3   Discrete representation of structuring element

In the process of filtering profiles, a circular disk is used, as outlined in Figure 2. Due its symmetry about the origin, it is sufficient to consider only its first quadrant form, and represent it discretely as the vector b. The same applies with a horizontal straight line segment, as shown in Figure 3. Again, due its symmetry about the origin, it is sufficient to consider only its right half, and represent it discretely as the vector b. The length of the structuring element vector b is much smaller than that of the input vector z. For ease of computation, input z and structuring element b are sampled at the same interval Δ.
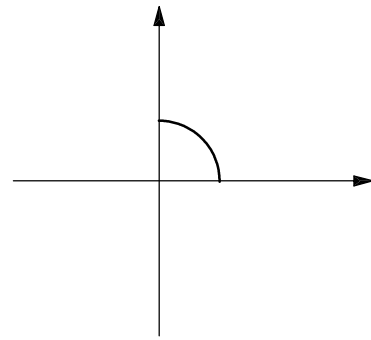

Key

X   distance, μm

Y   height, μm

Figure 1 — Example of extracted profile graphed after linear interpolation of its discrete representation
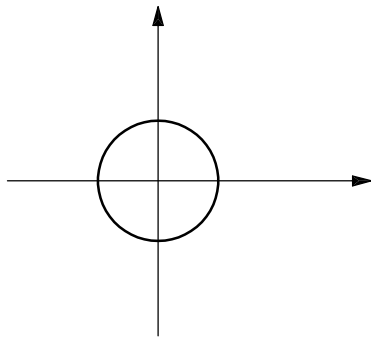
a) Representation in full form

b) Representation in economic form in the first quadrant due to its symmetry

NOTE   For example, an economic representation of a circular disk of radius 2 µm is b = [2,000 0; 1,936 5; 1,732 1; 1,322 9; 0], where the dimensions are in µm and the sampling interval is 0,5 µm. In Figure 2 b), only the circular arc in the first quadrant is represented due the symmetry of the circular disk.

Figure 2 — Example of a circular disk structuring element

a) Representation in full form

b) Representation in economic form showing only its right half due to its symmetry

NOTE   An economic representation of a horizontal line-segment of total length 4 µm is b = [0, 0, 0, 0, 0], where the dimensions are in µm and the sampling interval is 0,5 µm. In Figure 3 b), only the right half of the line-segment is represented due the symmetry of the line-segment.

Figure 3 — Example of a horizontal line-segment structuring element

4.4   Discrete morphological filters

A discrete morphological filter takes z and b as input and produces a filtered output of the same array length as the input z. It is a discrete representation of the filtered profile. The basic idea behind the computation of dilation and erosion is to position the origin of the structuring element at every point of the input and to sum them, as illustrated for a few positions of a circular structuring element for dilation in Figure 4. The extreme value at each sampling point is then collected and these values are reported as the output. For example, in Figure 4, the top-most star in each vertical line is collected after all the disks are positioned, and the array of the vertical coordinates of all the top-most stars form the output for dilation.
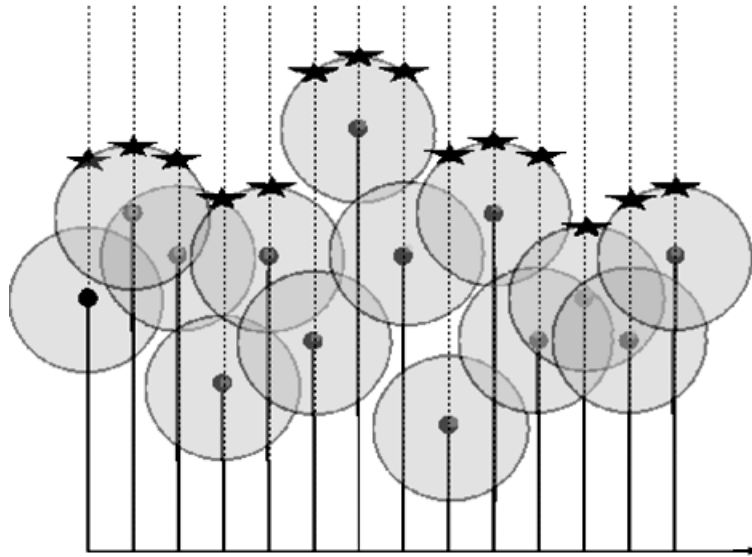
NOTE   The centre of the disk is positioned at every input data point. The stars are the maximum height of all the results calculated by adding the coordinates of input points (filled dots) to the coordinates of sampled points on the circle.

Figure 4 — Illustration of dilation with a circular disk

Closing and opening filters can be computed by applying the dilation and erosion in a specific sequence. Figure 5 illustrates how an input profile is dilated and eroded by a disk structuring element. Figures 6 and 7 show the results of opening and closing filters. In these figures, the input function and the structuring element are uniformly sampled at 0,5 μm intervals. In general, dilation and closing produce outputs that are above the input function (extensivity), whereas erosion and opening result in outputs that are below the input function (anti-extensivity). Figures 8, 9 and 10 show the effect of a horizontal line-segment structuring element.

NOTE   The same technique of positioning, summing and taking the extremes can be applied to discrete morphological filtering of surfaces.

Key
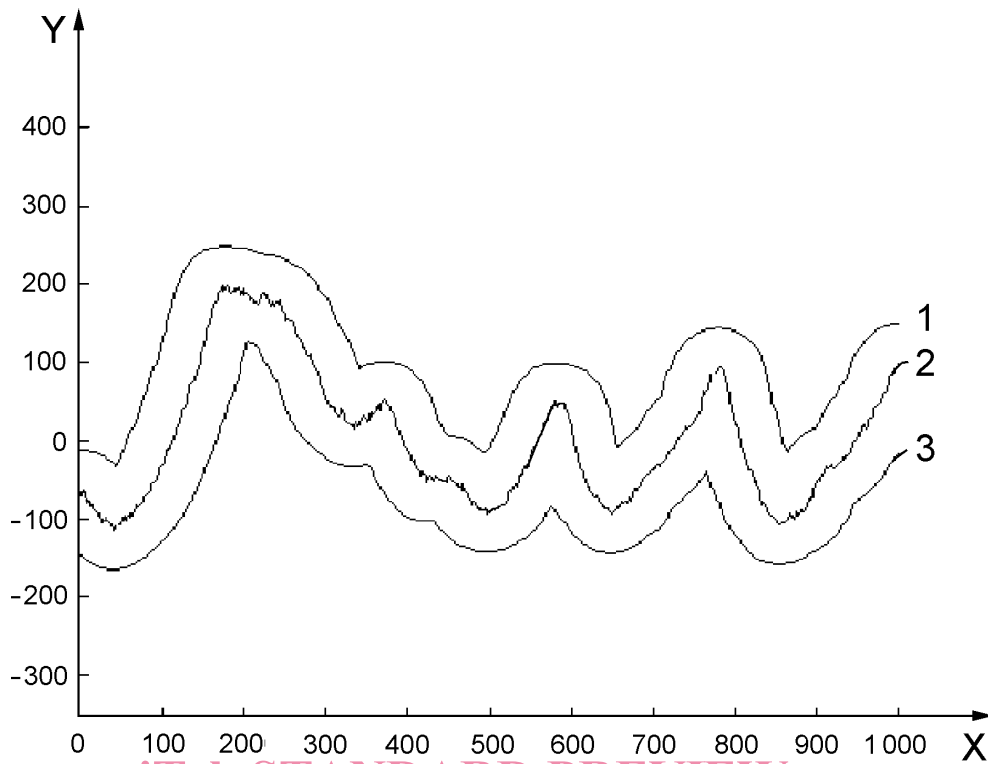
X   distance, μm

Y   height, μm

1   dilation

2   input function

3   erosion

Figure 5 — Input profile, its dilation and its erosion by a circular disk of 50 μm **radius**