**BESCHWERDEKAMMERN
DES EUROPÄISCHEN
PATENTAMTS**

**BOARDS OF APPEAL OF
THE EUROPEAN PATENT
OFFICE**

**CHAMBRES DE RECOURS
DE L'OFFICE EUROPÉEN
DES BREVETS**

Internal distribution code:

(A) [-] Publication in OJ
(B) [-] To Chairmen and Members
(C) [-] To Chairmen
(D) [X] No distribution

**Datasheet for the decision
of 11 February 2022**

Case Number:	T 1482/19 - 3.5.06
Application Number:	14752573.7
Publication Number:	3025273
IPC:	G06K9/46
Language of the proceedings:	EN

Title of invention:
KEYPOINT IDENTIFICATION

Applicant:
Telecom Italia S.p.A.

Headword:
Scale space approximation/TELECOM ITALIA

Relevant legal provisions:
EPC Art. 56, 84, 123(2)
EPC R. 139
RPBA 2020 Art. 13(1), 13(2)

Keyword:
Inventive step - (yes) - technical problem derivable from the application as filed (yes) - long felt need (no)
Claims - functional features (yes)
Amendments - extension beyond the content of the application as filed (no)
Correction of error - obvious error
Amendment to appeal case - amendment detrimental to procedural economy (no) - suitability of amendment to resolve issues raised (yes)
Amendment after summons - exceptional circumstances (yes)

Decisions cited:
T 1294/16

Catchword:

D E C I S I O N
of Technical Board of Appeal 3.5.06
of 11 February 2022

Appellant: (Applicant)	Telecom Italia S.p.A. Via Gaetano Negri, 1 20123 Milano (IT)
Representative:	Maccalli, Marco Maccalli & Pezzoli S.r.l. Via Settembrini, 40 20124 Milano (IT)
Decision under appeal:	**Decision of the Examining Division of the European Patent Office posted on 20 November 2018 refusing European patent application No. 14752573.7 pursuant to Article 97(2) EPC.**

Composition of the Board:

Chairman	M. Müller
Members:	T. Alecu
	A. Jimenez

Summary of Facts and Submissions

I.   The appeal is against the decision of the Examining
        Division to refuse the application. For all requests,
        the decision was based on a lack of compliance with
        Article 84, Article 123(2) and Article 56 EPC. The
        decision cited inter alia the following documents:

        D1:   J Ng et al: "Steering in Scale Space to Optimally
              Detect Image Structures", 2004
        D4:   D.G. Lowe: "Distinctive Image Features from
              Scale-Invariant Keypoints", 2004

II.   With the grounds of appeal the appellant requested that
        the decision of the Examining Division be set aside and
        that a patent be granted on the basis of the main
        request or of one of seven auxiliary requests, all
        filed with the grounds of appeal. The sixth and seventh
        auxiliary requests were identical to the first and
        second auxiliary requests refused by the Examining
        Division.

III.   In the preliminary opinion accompanying a summons to
        oral proceedings the Board indicated that it tended to
        agree with the position of the Examining Division, that
        all requests on file lacked compliance with
        Articles 56, 84 and 123(2) EPC. However, it also stated
        that the third auxiliary request had the potential of
        defining inventive subject matter, if re-drafted in a
        form allowable under Articles 84 and 123(2) EPC. The
        Board further noted an error in the application
        documents, at equation 9 on page 12 of the description.

IV.   In reply to the summons the appellant filed a new
        page 12 as a correction under Rule 139 EPC. It also

filed three new requests, labeled A, B and C, based on the said third auxiliary request, replacing all previous requests. During the oral proceedings, the appellant filed a new request, labeled C - revision 3, replacing all previous requests.

V.   The final request of the appellant was therefore that the decision under appeal be set aside and that a patent be granted on the basis of the set of claims according to request C - revision 3 filed during the oral proceedings, page 12 as filed before the oral proceedings, and the remainder of the application documents as originally filed.

VI.   At the end of the oral proceedings, the chairman announced the Board's decision.

VII.   Claim 1 of the only request on file reads as follows:

"A method for identifying keypoints in a digital image (I) comprising a set of pixels, each pixel having associated thereto a respective value of an image representative parameter, said method comprising:
   - approximating (108), without explicitly computing, a filtered image (L(σ), 102) of said digital image (I), said filtered image being obtained from said digital image (I) by means of a filtering function, said filtering function being a Laplacian of Gaussian or a Difference of Gaussians and having a filtering parameter (σ) being the standard deviation of the Gaussian function, said approximating comprising:
   a) generating (102) a set of base filtered images (L(σ_i)) of said digital image (I), each base filtered image (L(σ_i)) being the digital image (I) filtered by means of a respective base filter, each base filter being a matrix the elements of which are obtained by

calculating said filtering function with a respective
value (σ_i) of the filtering parameter;

   b) for each pixel (x_t, y_t) of at least a subset of
said set of pixels of the digital image (I),
approximating (106) the filtered image (L(x_t, y_t, σ))
obtained from said digital image (I) by means of said
filtering function having a filtering parameter value
by means of a respective approximation function based
on the base filtered images, said approximation
function being a function of the filtering parameter
(σ) within a predefined range (104) of values of the
filtering parameter (σ), said predefined range ranging
from a lowest value of the filtering parameter to a
highest value of the filtering parameter, wherein:

   - wherein said approximating function is a
polynomial expressed as follows:

$$(13):\ \mathrm{L}\,(\mathrm{x, y, \sigma}) \approx c_r(\mathrm{x, y})\sigma^r + c_{(r-1)}(\mathrm{x, y})\sigma^{(r-1)} + \cdots + c_1(\mathrm{x, y})\sigma + c_0(\mathrm{x, y})$$

wherein
   L(x, y, σ) is the filtered image to be approximated
   c(x, y) is the polynomial coefficient for σ^r

wherein said polynomial coefficients c_r(x, y) are
obtained as a linear combination of said base filtered
images according to the following equations:

$$[c_r(x,y)\ c_{r-1}(x,y)\ \ldots\ c_1(x,y)\ c_0(x,y)]$$
$$= [L(x,y,\sigma_1)(:)\ L(x,y,\sigma_2)(:)\ L(x,y,\sigma_{n-1})(:)\ L(x,y,\sigma_n)(:)]F^T$$

wherein F^T is calculated by solving the following
equation:
   SF=W^T
wherein:

F is the unknown which, after being calculated and transposed, gives F^T

S is a matrix formed by specific values of σ_i as follows:

$$S = \begin{bmatrix} (\sigma'_1)^r & \cdots & (\sigma'_1)^2 & (\sigma'_1)^1 & 1 \\ (\sigma'_2)^r & \cdots & (\sigma'_2)^2 & (\sigma'_2)^1 & 1 \\ (\sigma'_3)^r & \cdots & (\sigma'_3)^2 & (\sigma'_3)^1 & 1 \\ \ddots & \ddots & \ddots & \ddots & \ddots \\ (\sigma'_q)^r & \cdots & (\sigma'_q)^2 & (\sigma'_{q1})^1 & 1 \end{bmatrix}$$

wherein σ'_i (with i varying from 1 to q) are specific values of the filtering parameter σ

W is a matrix calculated by solving the following equation:

   AW = D

wherein
    A is a matrix formed by the base filters, wherein
    matrix A has a number of columns equal to the
    number of base filters, wherein each column of
    matrix A represents a respective base filter,
    wherein each column of matrix A is built by
    arranging in columns the columns of each base
    filter
    D is a matrix each element of which is obtained by
    calculating the filtering function, for each point
    (x, y) and for each of said specific values σ'_j
    (with j varying from 1 to q)
    W is the unknown which, after being calculated and
    transposed, gives W^T

   - for each pixel of said at least a subset,
identifying (120) such pixel as a candidate keypoint

if, in such pixel, the approximation function has a local extreme (110) which is also a global extreme (116) with respect to the filtering parameter (σ) for a value σ_m of the filtering parameter in a respective sub-range of values of the filtering parameter internal to said predefined range said respective sub-range having a lower end larger than said lowest value of the filtering parameter and an upper end lower than said highest value of the filtering parameter, wherein the difference between said lowest value and said lower end, and the difference between said highest value and said upper end, are such that only the maximum or minimum points that happen in σ_m of which the behavior of the approximation function is known in a neighborhood of σ_m that is sufficiently large are considered as candidate keypoints;

   - for each pixel identified as a candidate keypoint:

   c) comparing (130) the value assumed by the approximation function at the value of the filtering parameter corresponding to the global extreme of the pixel with the values assumed by the approximation functions of the pixels adjacent to said pixel in the image at the values of the filtering parameters of the respective global extremes of such adjacent pixels, and

   d) selecting (136) such pixel based on this comparison."

Reasons for the Decision

The application

1.   The application relates to identifying so-called keypoints in a digital image, for e.g. scene or object identification/matching.

1.1   It builds upon the known method of scale invariant
        feature detection (SIFT keypoints, see D4, cited in the
        application on page 2), which detects keypoints as
        extrema in the image "scale space" (D4, section 3). The
        image scale space is obtained by convolving (filtering)
        the original images with a Gaussian function of varying
        widths; its standard deviation defines the scale
        dimension of the image "scale space". The extrema are
        not detected in the scale space itself, but in the LoG
        space (Laplacian of Gaussian, second derivative with
        respect to scale), approximated in SIFT feature
        detection by the difference of two adjacent in a
        sequence of scale filtered images (difference of
        Gaussian - DoG, see D4, section 3).

1.2   The application proposes a method of approximating the
        scale space by a continuous function of scale,
        determined as a linear combination of filter responses
        at fixed scales σ_1 ... σ_n (basis scales - see
        equation 1), the combination weights $p(\sigma)$ themselves
        being determined as a polynomial function of scale
        (equation 8). The determination of the polynomials
        entails two steps: first the basis scales and a set of
        scales of interest are selected (page 10, paragraph
        before equation 5, page 15, 1st paragraph). The
        combination weights for expressing the filters at the
        scales of interest as a linear combination of the basis
        filters can be determined by solving a linear system
        (equations 4 and 5). Then, polynomials coefficients are
        determined to best approximate these weights as a
        function of scale.

1.3   Under this approximation, given an image, the responses
        to the basis filters are computed and treated as
        constants. Then, the scale space response can be
        approximated at each image point as a polynomial

(equations 12 and 13). This allows the analytical computation of extrema points by computing the roots of the polynomial (page 16, paragraph 2: first derivative equals 0). The application proposes to select "global" extrema points, also verifying whether the local extrema are extrema in view of the end points of the scale range (page 16).

1.4   The application further proposes (page 17, first full paragraph) to select as keypoints only points in a restricted working range, where the behavior of the approximation function is known.

Rule 139 EPC

2.   The Board accepts the request for correction under Rule 139 EPC. The error is obvious, at least because it is not consistent with the description in the paragraph following it, and with other equations, see e.g. equation 11. The correction is unambiguous, as correctly explained by the appellant in its letter dated 4 February 2022, and reflects what was originally intended.

The decision under appeal

3.   The Examining Division refused the application on three main grounds. The first one (points 1.1 and 1.2), under Article 84 EPC, relates to the definition of the scale space in that the filtering function was not specified to be a LoG or DoG function (feature considered necessary to detect keypoints).

4.   The second one (points 1.3 and 3.1) was related to the definition of the approximation function and it was found, essentially, that the application as filed only provides support for an approximation as provided in

equation 12, read together with equations 5, 8 and 9 defining the polynomial coefficients and their computation. The claimed generalizations were not allowable under Article 123(2) EPC. Furthermore, the attempts at formulating these equations (in text form) led to lack of clarity and conciseness (Article 84 EPC).

5.   The third one was that the claimed subject-matter, even if considering the subject matter to be limited as defined in those equations (point 2), was obvious in view of a combination of D1 with D4 (points 2.1 to 2.6).

Admittance (Article 13 RPBA 2020)

6.   The current request C - version 3 was filed during oral proceedings before the Board. Though it certainly could, and should, have been filed earlier, it also remedied to all objections brought forward in the preliminary opinion of the Board, by taking guidance on point 23 therein. The Board regards this as sufficient reasons for allowability under Article 13(1) RPBA 2020.

6.1   Regarding Article 13(2) RPBA 2020, the Board finds that exceptional circumstances are established in that a request which is clearly allowable, as is the case here, brings the procedure to an end (see also T 1294/16, points 18.2 and 18.3).

Articles 123(2) EPC and 84 EPC

7.   Claim 1 of the only request on file defines, in summary, a method of identifying keypoints in a digital image, comprising:
        first claim feature: using an image scale space defined by a LoG or a DoG filter,

<u>claim features a and b</u>: defining, for each pixel, a polynomial approximation of this scale space (reciting equations 12 and 13) in a predefined range of scales, this approximation being obtained in two steps in accordance with equations 5 (approximation of the scale space as a linear combination of the base filters), 8 and 9 (approximation of the weights as polynomial functions of scale) and

> <u>last paragraph of claim feature b</u>: identifying candidate keypoints in this scale space as global extremes of the approximation function which are found in a sub-range defined by its lower and upper ends so that the behavior of the approximation function is known in a sufficiently large neighborhood of the extremum

<u>claim features c and d</u>: comparing, for each pixel identified as candidate keypoint, the value of the approximation functions at said extremum with those of neighboring pixels to select the pixel or not.

8.   This claim is based on original claim 1 modified in the first claim feature to define the LoG/DoG filters (see e.g. original claim 11), amended in features a and b to define the approximation used in accordance with equations 5, 8, 9, 12, 13, and further amended (last paragraph of feature b) to define the selection of candidate keypoints in a sub-range.

9.   The first two amendments remedy the deficiencies noted by the Examining Division in terms of original disclosure, support and clarity (Articles 123(2) and Article 84 EPC).

10. The last amendment is based on page 17, lines 7 to 13, defining the lower and upper ends of the sub-range in

respect of the highest and lowest value of the sub-range as follows:

wherein the difference between said lowest value and said lower end, and the difference between said highest value and said upper end, are such that only the maximum or minimum points that happen in σ_m of which the behavior of the approximation function is known in a neighborhood of σ_m that is sufficiently large are considered as candidate keypoints.

10.1   In the Board's view, this formulation follows unambiguously from the explanation provided in the said passage on page 17 that by restricting the selection to a sub-range, only the extrema that happen in a neighbourhood where the behavior of the approximation function are known are considered (*in this way*...). Though a verb is missing in the sentence on lines 12 and 13, it is clear that the discussion is about which keypoints are to be considered - see the beginning of the paragraph. Thus no objection under Article 123(2) EPC arises.

10.2   Though functional, the definition of the sub-range is clear to the skilled person, who, in the context of the application, is deemed to have expertise in applied mathematics, in particular in approximation functions. Analysing the behavior of polynomial approximations around the interpolating points and on the borders so as to appreciate the validity of the approximation (e.g. estimating the errors' order of magnitude) is a matter of routine in this context. Thus no objection under Article 84 arises either.

Inventive step (Article 56 EPC)

11.   The Examining Division rejected the requests underlying
        their decision for a lack of inventive step starting
        from D1 in view of D4. These reasons are also pertinent
        for the current request and are discussed below.

12.   Document D1 describes a method of scale space approxi-
        mation which is the same as that of the application
        (see D1, equations 5 to 15). This was also stated in
        the decision at point 2 and was not denied by the
        appellant.

12.1   The purpose of D1 is (introduction, page 483,
        paragraph 2) to address the "*main problem ... that
        exhaustive filtering with kernels over a wide range of
        finely-sampled scales is computationally intensive and
        inefficient*". The proposed method, by the formulation
        of what are called polynomial steering functions "*lends
        itself well to the detection of global maxima by
        analytically finding the roots of the derivatives of
        the polynomials, rather than exhaustively performing
        operations over multiple scales to detect maxima as in
        the previous aforementioned works*" (section 4,
        paragraph 1).

12.2   D1 uses global maxima over scales (section 4) to detect
        the scale of image structures in order to improve low-
        level feature detection and extraction by spatial
        filters (introduction). It is said though that the
        other polynomial roots "provide scale information about
        the other local energy maxima, minima and inflection
        points" (conclusion, last paragraph).

13.   Document D4 represents the seminal work of Lowe regar-
        ding keypoint detection with scale invariant features.

The method starts (section 3) by detecting local ex-
trema in (DoG) scale space. These local extrema are
obtained by comparing the value of a point with its
neighbours both in the scale and the spatial direction
(adjacent points - see figure 2). This raises the ques-
tion of the sampling frequency in both scale and space
domains (section 3.1). D4 uses experimentation in order
to determine the frequency of sampling in the scale
domain and "*must settle for a solution that trades off
efficiency with completeness*" (end of section 3.1). To
reduce computation, D4 further proposes to work on
octaves (where the scale doubles), i.e. to repeat the
method with the same set of scales, but on reduced
versions of the image for each octave (see figure 1).

14.   The Examining Division reasoned (2.4) that keypoint
        detection was a form of low-level feature detection and
        that it was commonly known to the skilled person that
        keypoint detection requires the same identification of
        scale space extrema. So the skilled person would use D1
        for keypoint detection.

14.1   The keypoint selection (steps c) and d)) based on the
        spatial comparison with 8 adjacent points would be done
        by the skilled person because it was commonly known to
        do so for keypoint detection (presumably from D4).
        There was no need to also compare with the neighbours
        in scale, because the extrema in scale were already
        determined.

14.2   Accordingly, the Examining Division concluded that all
        claim features except for the last paragraph in feature
        b were obvious for the skilled person over the
        combination of D1 and D4.

14.3   Regarding the last feature - in its previous wording,
        defining a sub-range separated from the ends of the
        predefined range by a fixed value of 0.1 - the
        Examining Division noted (2.4.1 and 2.4.2) that the
        technical effect of eliminating unstable keypoint
        candidates was plausible, but could only be understood
        with hindsight, and could not be based on the
        corresponding disclosure on page 17. As a consequence,
        the Examining Division did not accept this feature to
        have the alleged effect (2.4.3, last sentence).

15.   The appellant disagreed with the choice of D1 as star-
        ting point (see the grounds of appeal, point 1.3.1).
        There was no mention of keypoint detection in D1, so
        using D1 for that purpose was not apparent to the
        skilled person starting from D1. D4 should be taken as
        the "closest prior art", because it addressed the same
        problem as the claimed invention, namely keypoint
        detection.

15.1   Further, the appellant argued (see the grounds of
        appeal, point 1.3.3) that the skilled person would not
        have combined D4 with D1, because D1 was about features
        such as edges and ridges (D1, abstract), whereas D4
        stated that edges were not good candidates for inclu-
        ding keypoints (D4, section 4.1). Moreover, D1 provided
        a 12th degree polynomial (see, e.g., equation 10),
        which - although being a polynomial - was clearly too
        complex to handle for keypoint identification. Even if
        the two documents were combined, the combined method
        would have resulted in computing the approximation of
        D1 at each considered point in D4 and comparing it with
        the 9-8-9-neighborhood as per D4 (figure 2).

16.   The Board remarks that document D4 is commonly known in
        the field of image analysis. A person skilled in this

art, i.e. the intended addressee of D1, would see that D1, although it mentions edges and ridges, proposes a general method of scale space approximation, which is said to be more computationally efficient than computation by discretization of the scale space. Furthermore, D1 teaches that with this approximation, for each image point, local and global extrema in scale can be computed analytically in an efficient way. So the skilled person would consider employing the method of D1 to improve the commonly known keypoint detection method of D4, which uses the standard scale space discretization.

17.   That said, the Board accepts that this way of presenting the argument does not follow the established (but not mandatory) problem-solution approach, according to which the starting point would be the prior art to be improved and the objective technical problem to achieve that improvement. One does not, however, come to a different conclusion that way.

17.1 Starting from D4, the skilled person would set out to improve the efficiency of the keypoint detection method, a matter already discussed in D4, section 3.1. In doing that, the skilled person would come across D1 which discloses a solution to this problem. As explained above, even though D1 does not expressly mention keypoints, the skilled person would not have any difficulty in realising that D1 can be employed to increase efficiency of the method of D4.

17.2 Since D1 emphasises the importance of global extrema, the skilled person would also identify, for each considered point, the global extremum among the local extrema.

17.3   Following the D4 structure, this extremum will be com-
        pared with those of the neighbours. However, using the
        continuous polynomial scale space approximation of D1,
        the comparison with the upper and lower 9 scale layer
        neighbors (figure 2 of D4) has no meaning, as those
        layers are not defined. But the spatial comparison with
        the 8 neighbors, as carried out in D4, remains valid.

18.   The appellant also asked the Board to further consider
        (i) that the invention responded to a long-felt need
        and was included in the MPEG-7 standard, and (ii) that,
        although D1 and D4 were published in 2004, no one had
        the idea the inventors had up until 2013.

18.1   Regarding the first point, the appellant has not elabo-
        rated on any specific "long-felt need" or demonstrated
        any failed attempts in the art to address it. For this
        reason alone, the appellant's argument must fail.

18.2   Regarding the second point, the Board notes that the
        obviousness of the claimed invention is assessed in an
        "objective" manner, i.e. irrespective what actually
        happened, by reference to what a fictitious skilled
        person "would have done". The Board believes that the
        link between D4 and D1, provided by the problem of
        efficiency, would have led the skilled person to con-
        sider their combination, irrespective of whether that
        had actually happened in the cited period.

19.   Thus the Board agrees in essence with the reasoning of
        the Examining Division regarding the combination of D1
        and D4, though indeed the natural starting point accor-
        ding to the problem-solution approach is D4 rather than
        D1, because D4 is improved by D1 and not vice versa. It

follows that all the claimed features but the last in feature b are obvious in view of said combination.

20.   Regarding this last feature, the Examining Division and the appellant agree that this step solves a technical problem in that it allows to eliminate spurious or unstable candidate keypoints, due to the effects of the approximation.

20.1   The Board also notes that the Examining Division did not find this feature obvious over D1 and D4 but did not accept that the alleged technical effect could be acknowledged based on the application documents as filed.

20.2   The Board accepts this as a legitimate concern but finds to the contrary. The skilled person understands from page 17 that by keeping only the points for which "*the behavior of the approximation functions are known in a neighborhood ... that is sufficiently large*", the points outside the validity range of the approximation are eliminated, and that these are potentially not true extrema, and hence no real keypoints, but are due to errors in the approximation. Thus the technical problem of eliminating "false" extrema is clear from the application.

21.   The Board concludes that claim 1 of the sole request involves an inventive step.

Other issues

22.   The Board has no objections as to the content of the dependent claims, or of the description.

Order

For these reasons it is decided that:

The decision under appeal is set aside.

The case is remitted to the examining division with the order
to grant a patent in the following version:

Description:
Pages 1-11, 13-24 as originally filed
Page 12 as filed with letter of 4 February 2022

Claims:
1-9 according to request "C" - revision 3 filed during the oral
proceedings of 10 February 2022

Drawings:
Sheets 1-16 as originally filed.

The Registrar: The Chairman:

L. Stridde   Martin Müller

Decision electronically authenticated