The opinion in support of the decision being entered today was _not_ written for publication and is _not_ binding precedent of the Board.

Paper No. 24

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE BOARD OF PATENT APPEALS
AND INTERFERENCES

Ex parte HIDEYA TAKEO
and NOBUYOSHI NAKAJIMA

Appeal No. 1999-2069
Application 08/397,639[1]

ON BRIEF

Before BARRETT, FLEMING, and BARRY, _Administrative Patent Judges_.

BARRETT, _Administrative Patent Judge_.

DECISION ON APPEAL

This is a decision on appeal under 35 U.S.C. § 134 from the final rejection of claims 1-5.

We affirm.

[1] Application for patent filed March 2, 1995, entitled "Method For Adjusting Positions Of Radiation Images," which claims the foreign filing priority benefit under 35 U.S.C. § 119 of Japanese Application 6-035850, filed March 7, 1994.

BACKGROUND

The invention is directed to a method for image registration (alignment) of two radiation images. One image is a reference image and the other image is spatially transformed so that points corresponding to points on the reference image match up. Spatial transformation and image registration are discussed in Gonzalez et al., Digital Image Processing (Addison-Wesley Pub. Co. 1992), pp. 298-302 (copy attached). The invention uses "affine transformations" to transform one image into the coordinates of the reference image. An "affine transformation" is a transformation in which straight lines remain straight and parallel lines remain parallel, whereas angles may undergo changes and differential scale changes may be introduced; e.g., a square could become a rhombus by scaling. Affine transformations are rotation, translation, and scale factor (magnification or reduction) operations.

Claim 1, the sole independent claim, is reproduced below.

> 1. A method for adjusting positions of radiation images, wherein the positions of a plurality of radiation images are matched to one another such that the radiation images may be subjected to superposition processing or subtraction processing,
>
> the method comprising the steps of:
>
> i) setting template regions on a single radiation image, which is among the plurality of the radiation images,

ii) carrying out template matching, with which said template regions are matched with the radiation images other than said single radiation image,

iii) thereby obtaining at least three corresponding points in each of the plurality of the radiation images,

iv) taking the corresponding points in a single radiation image, which is among the plurality of the radiation images, as reference corresponding points,

v) calculating factors of affine transformation with the method of least squares, said affine transformation being represented by the formula

$$\begin{pmatrix} u \\ v \end{pmatrix} = \begin{pmatrix} a & b \\ c & d \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix} + \begin{pmatrix} e \\ f \end{pmatrix}$$

wherein u and v represent the coordinates of the reference corresponding point, x and y represent the coordinates of the corresponding point to be transformed, a, b, c, and d are the factors representing correction with a rotating operation and correction with an enlargement or reduction factor, and e and f are the factors representing correction with parallel translation, and

vi) carrying out affine transformation, in which the calculated factors of affine transformation are used, and with which the values of coordinates of the corresponding points in the radiation images other than said single radiation image having the reference corresponding points are transformed into values of coordinates of the reference corresponding points such that the reference corresponding points and the transformed corresponding points in the radiation images other than said single radiation image having the reference corresponding points may coincide with one another;

wherein said affine transformation step is performed so that each of enlargement or reduction, rotation, and parallel translation of the radiation images, other than said single radiation image, occur simultaneously.

The Examiner relies on the following prior art:

Komaki et al. (Komaki)	4,356,398	October 26, 1982
Weiman	5,063,604	November 5, 1991
Kano et al. (Kano)	5,359,513	October 25, 1994 (filed November 25, 1992)
Smilansky et al. (Smilansky)	5,495,535	February 27, 1996 (§ 102(e) date September 24, 1993)
Frankot et al. (Frankot)	5,495,540	February 27, 1996 (effective filing date February 8, 1993)

Barnea et al. (Barnea), A Class of Algorithms for Fast Digital Image Registration, IEEE Trans. on Computers, Vol. C-21, No. 2, February 1972, pp. 179-186.

Claims 1 and 3 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Kano in view of Smilansky or Frankot.

Claim 2 stands rejected under 35 U.S.C. § 103(a) as being unpatentable over Kano in view of Smilansky or Frankot as applied in the rejection of claim 1, further in view of Komaki.

Claim 4 stands rejected under 35 U.S.C. § 103(a) as being unpatentable over Kano in view of Smilansky or Frankot as applied in the rejection of claim 1, further in view of Barnea.

Claim 5 stands rejected under 35 U.S.C. § 103(a) as being unpatentable over Kano in view of Smilansky or Frankot as applied in the rejection of claim 1, further in view of Weiman.

We refer to the final rejection (Paper No. 8) (pages referred to as "FR__") and the examiner's answer (Paper No. 21) (pages referred to as "EA__") for a statement of the Examiner's position, and to the appeal brief (Paper No. 19) (pages referred to as "Br__") and the reply brief (Paper No. 22) (pages referred to as "RBr__") for Appellants' arguments thereagainst.

OPINION

Claims stand or fall together with claim 1

In the main appeal brief, claims 1-5 are grouped to stand or fall together (Br5). This means that the patentability of dependent claims 2-5 is determined by the patentability of independent claim 1. Appellants presented no arguments regarding claims 2-5 or the references applied to those claims. In the reply brief, Appellants argue that claims 1 and 2 do not stand or fall together and that claim 2 was specifically addressed by Appellants beginning on page 12 of the April 4, 1997, amendment (RBr2). Appellants then argue claim 2 and Komaki (RBr2-4). The Examiner acknowledges that the reply brief has been entered and considered, but states that no further response is necessary (Paper No. 23).

"Any arguments or authorities not included in the brief will be refused consideration by the Board of Patent Appeals and Interferences, unless good cause is shown." 37 CFR § 1.192(a) (1998). No explanation for the failure to argue claim 2 in the brief has been offered. These arguments presented for the first time in the reply brief are untimely and will not be considered. Cf. Kaufman Company, Inc. v. Lantech, Inc., 807 F.2d 970, 973 n.*, 1 USPQ2d 1202, 1204 n.* (Fed. Cir. 1986); McBride v.

Merrell Dow and Pharmaceuticals, Inc., 800 F.2d 1208, 1210-11 (D.C. Cir. 1986) ("We generally will not entertain arguments omitted from an appellant's opening brief and raised initially in his reply brief. . . . Considering an argument advanced for the first time in a reply brief, then, is not only unfair to an appellee, . . . but also entails the risk of an improvident or ill-advised opinion on the legal issues tendered."). The Examiner was not permitted to file a supplemental examiner's answer under the new rules, 37 CFR § 1.193(b(1), effective October 10, 1997, and it would be unfair to permit Appellants to present arguments to which the Examiner could not respond.

Because the claims are grouped to stand or fall together with claim 1, the only issue is whether claim 1 is patentable over Kano in view of Smilansky or Frankot.

Obviousness

Kano teaches image registration (alignment of two images) of two radiation images so that the images can be subjected to subtraction processing (e.g., col. 5, lines 60-64; Fig. 1B); thus, Kano teaches the limitations of the preamble of claim 1. Kano teaches that the nonlinear warping (transformation) is performed based on local matchings of a number of small regions of interest (ROIs) at corresponding locations in the two images (e.g., col. 5, lines 64-67), so the following steps are performed at several locations. Kano teaches that a small template ROI is selected in one image; thus, Kano teaches step i) of setting template regions on a single radiation image. Kano discloses using a local matching technique to determine the subregion in a search ROI which produces the "best" match with a corresponding template ROI (e.g., col. 6, lines 1-11; col. 7, lines 22-28); thus, Kano teaches step ii) of carrying out template matching in the other image. Kano teaches that by applying a local matching technique to the template ROI and the search ROI, the Cartesian coordinate location of the center of the "best" match subregion can be found, which is indicated by (x',y') (e.g., col. 6, lines 20-22; col. 9, lines 14-18) and this is done for a number of pairs of templates (col. 9, lines 21-26), which is many more than three corresponding points as shown in Fig. 6 and Fig. 9 (each intersection point is transformed); thus, Kano teaches step iii) of obtaining at least three corresponding points in the two radiation images. Kano teaches that points in one image are reference corresponding points (Fig. 9; col. 12, lines 8-16) as recited in step iv).

The Examiner finds that the difference between the subject matter of claim 1 and Kano is that "Kano uses a nonlinear warping transform before subtraction rather than an affine transformation" (EA4). We agree that Kano does not disclose step v) of calculating factors of affine transformation or step vi) of carrying out the affine transformation. An "affine transformation" is a special transformation that involves only rotation, scaling, and translation, and does not contain any terms greater than first order (e.g., x^2) or any cross-product terms (e.g., xy). For example, to translate a point (x,y) to a new point (u,v) by a combination of rotation, translation, and scaling, an affine transformation has the general form:

$$u = ax + by + e$$
$$v = cx + dy + f$$

The "nonlinear warping transformation" of Kano (col. 12, lines 18-24; note that "i–0" should be "i=0") includes the terms above in addition to other terms and does not put any limitations on the terms a, b, c, and d.[2] Kano involves a more complex transformation than an affine transformation and can correct for greater distortion. Kano discloses that there are many sources of misregistration between image pairs due to movements of the

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[2] An affine transformation constrains $a=S_x\cos\theta$, $b=-S_x\sin\theta$, $c=S_y\sin\theta$, $d=S_y\cos\theta$, where S_x and S_y are scaling factors in the x and y direction, respectively. This means that the values of a, b, c, and d are not completely independent. Therefore, the Examiner's statement that "equation 4 of [sic, unnumbered equations at col. 12, lines 18-24] Kano et al. not only provides for the translation term 'a_1' and the two first order terms that belong to the affine transformation, but also for higher terms as well for 'accuracy'" (EA11), is not strictly correct. The nonlinear transformation in Kano is of the form "u = ax + by + e + cross-product and higher order terms, "v = cx + dy + f + cross-product and higher order terms," but the coefficients a, b, c, and d do not necessarily define an affine transformation.

three-dimensional body being imaged and that most pairs have misregistration due to a combination of these sources (col. 1, lines 64-68; Fig. 12). Kano utilizes nonlinear warping in order to obtain improved registration between the two images (col. 5, lines 60-64) which can be quite distorted (Figs. 9A&9B).

The Examiner finds that Smilansky and Frankot perform image registration utilizing an affine transformation by calculating the factors of affine transformation with the method of least squares and then carrying out the affine transformation (FR5-6; EA5-6). The Examiner concludes that it would have been obvious to one of ordinary skill in the art to use an affine transformation as taught by Smilansky for aligning the images in Kano "since an affine transformation compensates for angular deviation and scaling errors . . . and also considers translation . . . and because it is very well known that the error on affine transformations can be minimized using least squares" (FR5; EA5). The Examiner concludes that it would have been obvious to use an affine transformation as taught by Frankot for aligning the images in Kano "since an affine transformation can be used to optimize for minimizing MSE (Mean Squared Error) and reducing computation" (FR6; EA6).

Smilansky discloses using an affine transformation to register the image of a PCB (printed circuit board) being inspected with a reference image (col. 6, line 41 to col. 7, line 29). Although Smilansky discusses rigid transformations (e.g., col. 11, lines 42-43), which involve rotation and translation, but not scaling, equation 1b shows the use of scaling in the general case, where S_x and S_y are scaling factors (and where α would normally be $\pi/2$ for no angular deviation of the sensor). Thus, Smilansky discloses affine transformations involving rotation, translation, and scaling (an enlargement or reduction factor). Smilansky discloses that a full affine transformation can be computed based on the theory of least-squares data fitting (col. 11, lines 15-34).

Frankot discloses that "[f]or any transformation more general than pure translation, scale factor (magnification) or rotation for example, registration effectiveness depends on the relative positions of each measurement in addition to the accuracy of the measurements themselves" (col. 1, lines 59-63), where we note that translation, rotation, and scale factor are affine transformations. Frankot discloses selection criteria for automatic subarea selection to improve image registration. Frankot discloses that "[i]mage registration requires estimation of the coordinate transformation f that aligns two images" (col. 6, lines 4-6). Frankot discloses that the transformation f may be an affine transformation (col. 8, lines 65-67) and that the coordinate transformation may be fitted with a weighted-least-squares method (col. 6, lines 23-30).

We find, based on Smilansky and Frankot, that persons of ordinary skill in the image registration art knew that affine transformations could be used for image registration and that the method of least squares was used to calculate the factors of affine transformation. One of ordinary skill in the art also knew from Kano that a complex nonlinear warping transformation could be utilized to obtain improved registration between two images where the distortion is significant. In our opinion, it would have been obvious to one having ordinary skill in the image registration art to replace the nonlinear warping transformation of Kano with any known transformation, including the simpler affine transformations (rotation, scaling, and translation), which are taught to be well known in Smilansky and Frankot, depending on the kind of distortion to be corrected. That is, it would have been generally obvious to one of ordinary skill in the art to go from a complex transformation to a known simple transformation if only a simple transformation is needed. Next, we consider Appellants' arguments.

Appellants argue (Br5):

> Kano et al. is directed to adjusting image interval changes such as a shape or size of a lung or heart or such as overlapping portions of ribs or veins. The interval changes are not analogous shifts, such as enlargement/reduction, rotation or parallel displacement, which are the subject of affine transformation. Therefore, Kano et al. is completely different from the present invention.

We generally agree with the Examiner's response (EA10-11), except for our comments in footnote 2. In addition, we note that an "interval change is defined here as a pathological change which has occurred after the previous examination and before the current examination" (Kano, col. 1, lines 48-51). The "interval change" has nothing inherently to do with the kind of shifts. Kano discloses causes of misregistration in Fig. 12, which involve translation (e.g., due to lung expansion), rotation (e.g., due to lateral inclination), and scaling (e.g., due to A-P inclination), as well as more complicated factors. Kano relates to image registration of radiation images and is very similar to the disclosed and claimed subject matter except that it relates to more complex misregistration problems. Appellants do not argue what language in claim 1 distinguishes over Kano.

Appellants argue that Smilansky does not suggest applying its inspecting method to radiation images (Br5). The Examiner responds that Kano, not Smilansky, is relied on for teaching subtraction of radiation images (EA11).

We agree with the Examiner. Smilansky evidences that one of ordinary skill in the image registration art had knowledge of affine transformations for image registration, in general. One of ordinary skill in the art would have been motivated to apply the affine transformations taught in Smilansky because they are known transformations for image registration, which are simpler than the nonlinear warping of Kano.

Appellants argue that Smilansky does not suggest adjusting positions of images for the purpose of adding and/or subtracting images and, therefore, does not provide any motivation to combine its teaching with those of Kano (Br5-6). The Examiner notes that claim 1 does not positively recite a step of subtraction, but that, in any case, Kano is relied on to show subtraction (EA11).

We agree with the Examiner. The rejection relies on Smilansky for its teaching that affine transformations were known transformations for image registration. Kano teaches subtraction in connection with image registration.

Appellants argue that Kano uses nonlinear warping rather than affine transformation because Kano's purpose is completely different than that of the present invention and "[t]herefore, it cannot be easily conceived for the ordinary skilled in the art to replace the non-linear warping of Kano et al. with the affine transformation of Smilansky et al., even if the equations used in each of these references are similar to each other" (Br6).

Kano "employs nonlinear distortion (warping) of one of the images in order to obtain improved registration between the two images so that subtraction processing can be carried out" (col. 5, lines 61-64). One of ordinary skill in the image registration art would have had sufficient skill to recognize that a less complex transformation, such as the affine transformations of Smilansky, could be used if the image registration did not need to be as accurate or address the same kind of distortions. It would have been obvious to one of ordinary skill in the art to replace a complex transformation with a known simple transformation, where one skilled in the art would have appreciated the limitations in image registration from making such a substitution.

Appellants argue that while Frankot describes affine transformations as an example of a means for adjusting positions using a selected subarea, "Frankot et al. does not teach that shifts in position among images are the problem when adding and/or subtracting radiation images, and also does not teach that affine transformation is used to solve the problem" (Br6).

Kano, not Frankot, is relied on for teaching subtracting registered radiation images. The general problem faced by Frankot and Kano is image registration. Frankot discloses affine transformation for image registration.

Appellants argue that one of ordinary skill would not have replaced the nonlinear warping of Kano with the affine transformation in Frankot (Br6). The Examiner points out that Frankot mentions second and higher order transformation models in addition to the first order affine transformation model and that this provides the suggestion for using different order transformation models in Kano (EA12).

We agree with the Examiner that Frankot's teaching of using different order transformation models would have suggested to one of ordinary skill in the art to use different order transformation models in Kano and, in particular, to use a lower order model for the more complex nonlinear transformation model.

For the reasons stated above, we conclude that Appellants have failed to persuade us of insufficient evidence to establish a prima facie case of obviousness. The rejections of claims 1-5 are sustained.

No time period for taking any subsequent action in connection with this appeal may be extended under 37 CFR § 1.136(a).

AFFIRMED

LEE E. BARRETT Administrative Patent Judge	)	
MICHAEL R. FLEMING Administrative Patent Judge	)	BOARD OF PATENT APPEALS AND INTERFERENCES

)
)
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