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UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

Ex parte MICHAEL GRASS,
ROBERT JOHANNES FREDERIK HOMAN, and
ROLAND PROKSA

Appeal 2020-000086
Application 15/756,605
Technology Center 2600

Before ALLEN R. MacDONALD, JASON V. MORGAN, and
JAMES B. ARPIN, *Administrative Patent Judges*.

MORGAN, *Administrative Patent Judge*.

DECISION ON APPEAL

STATEMENT OF THE CASE

Introduction

Pursuant to 35 U.S.C. § 134(a), Appellant[1] appeals from the Examiner's decision to reject claims 1–20. We have jurisdiction under 35 U.S.C. § 6(b).

We affirm.

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[1] We use the word "Appellant" to refer to "applicant" as defined in 37 C.F.R. § 1.42. Appellant identifies the real party in interest as Koninklijke Philips N.V. Appeal Br. 2.

Summary of the Disclosure

Appellant's claimed subject matter relates to the generation of a motion corrected computed tomography (CT) image. Abstract.

Exemplary claim (*key limitations emphasized*)

> 1. A computed tomography image generation apparatus for generating an image of a human head, wherein the computed tomography image generation apparatus comprises:
>
> a projections providing unit implemented by a computer processor for providing measured two-dimensional projections of the head, wherein the measured projections have been measured at different times while an x-ray tube, which emits radiation for traversing the head, has been moved around the head and wherein the measured projections have been generated based on the radiation after having traversed the head;
>
> a reconstruction unit implemented by the computer processor for reconstructing a three-dimensional first computed tomography image of the head based on the provided measured projections;
>
> a transformation determination unit implemented by the computer processor for *determining three-dimensional transformations of the first computed tomography image of the head for different measured projection groups*, wherein a measured projection group comprises one or several measured projections, *wherein the transformation determination unit is adapted to determine for a certain measured projection group a transformation such that a degree of similarity between the certain measured projection group and a calculated projection group is increased, wherein the calculated projection group* corresponds to the certain measured projection group and *is calculated by transforming the first computed tomography image in accordance with the determined transformation for the certain measured projection group and by forward projecting the transformed first computed tomography image*;
>
> wherein the reconstruction unit is adapted to reconstruct a motion corrected three-dimensional second computed

> tomography image based on the measured projections and the determined transformations determined for the different measured projection groups; and
>
> wherein the computed tomography image generation apparatus comprises an examination zone comprising a first part that includes the human head and a second part wherein the reconstruction unit is adapted to reconstruct the first computed tomography image and the second computed tomography image such that they show the examination zone and is further adapted to perform a motion correction only for the first part of the examination zone.

The Examiner's Rejections and Cited References

The Examiner rejects claims 1, 5, 14, 15, and 20 under 35 U.S.C. § 103 as unpatentable over the combined teachings of Kerstin Müller et al., *Fully Automatic Head Motion Correction for Interventional C-arm Systems using Fiducial Markers*, Procs. of the 13th Fully Three-Dimensional Image Reconstruction in Radiology and Nuclear Med., 534–37 (June 2015) (preprint version) ("Müller") and Barfuss et al. (US 2013/0202171 A1; published Aug. 8, 2013) ("Barfuss"). Final Act. 14–21.

The Examiner rejects claims 1, 4, 6, 10–16 and 19 under 35 U.S.C. § 103 as unpatentable over the combined teachings of Andre Z. Kyme et al., *Practical Aspects of a Data-Driven Motion Correction Approach for Brain SPECT*, IEEE Transactions on Med. Imaging, vol. 22, no. 6, 722–29 (June 2003) ("Kyme") and Barfuss. Final Act. 21–34.

The Examiner rejects claims 2 and 17 under 35 U.S.C. § 103 as unpatentable over the combined teachings of Kyme, Barfuss, and I.M.J. van der Bom et al., *Evaluation of optimization methods for intensity-based 2D-3D registration in x-ray guided interventions*, Med. Imaging 2011: Image

Processing, Proc. of SPIE, vol. 7962, 1–15 (Mar. 2011) ("Van der Bom"). Final Act. 34–36.

The Examiner rejects claims 3 and 18 under 35 U.S.C. § 103 as unpatentable over the combined teachings of Kyme, Barfuss, and Pelc et al. (US 4,580,219; issued Apr. 1, 1986) ("Pelc"). Final Act. 36–37.

The Examiner rejects claims 7 and 9 under 35 U.S.C. § 103 as unpatentable over the combined teachings of Kyme, Barfuss, and Quist (US 2006/0188134 A1; published Aug. 24, 2006). Final Act. 37–40.

The Examiner rejects claim 8 under 35 U.S.C. § 103 as unpatentable over the combined teachings of Kyme, Barfuss, and Allmendinger et al. (US 2015/0063534 A1; published Mar. 5, 2015) ("Allmendinger"). Final Act. 40–42.

ANALYSIS

Claim 1 recites an apparatus that reconstructs a three-dimensional first computed tomography image of a head based on projections measured at different times from an x-ray tube that emits radiation while moving around the head. *See, e.g.*, Spec. Fig. 2 (illustrating a first computed tomography image). "Patients like acute stroke patients may not be able to avoid motion during the acquisition of the projections such that the reconstructed image of the head may comprise motion artifacts" (Spec. p. 1, ll. 18–20) such as motion artifacts 19 depicted in the Specification's Figure 2 (*id.* p. 11, ll. 20–21). To correct for such motion, the claimed apparatus determines three-dimensional transformations of the first computed tomography image that increase the degree of similarity (i.e., decrease discrepancies) between measured projections and projections that are calculated by forward projecting the first computed tomography image as transformed by the three-dimensional transformations. *See id.* p. 12, l. 2–p. 13, l. 4, Fig. 3 (illustrating a calculated projection obtained by forward projecting a first computed tomography image), Fig. 4 (illustrating a gradient angle difference image). "The transformations determined for the different measured projection groups"—i.e., for different subsets of measured projections—"describe the motion of the head." *Id.* p. 13, ll. 24–25. Thus, the claimed apparatus uses the transformations "to reconstruct a motion corrected three-dimensional second computed tomography image based on the measured projections." *Id.* p. 13, ll. 26–28.

The Examiner finds that Müller fits a forward projection of three-dimensional reference marker positions to actual two-dimensional candidate points. *See, e.g.*, Final Act. 15 (citing Müller at *2). Thus, the Examiner finds that Müller's method increases "the degree of similarity, between $r'_{i,j}$ and $m_{i,j}$, which are the positions of markers identified in the calculated (transformed) projection group and the measured projection group, respectively." *Id.* at 13; *see also* Ans. 36. The Examiner further finds that Müller's pre-calibrated projection matrix teaches or suggests the determined transformation. *See* Final Act. 13; Adv. Act. 2 (Feb. 11, 2019) ("[T]he pre-calibrated projection matrix is still a transformation that is determined"); Ans. 34.

Appellant contends the Examiner erred in finding that Müller teaches or suggests the apparatus of claim 1 because Müller does not determine a transformation that "increases a degree of similarity between [a] certain measured projection group and a calculated projection group." Appeal Br. 6. Rather, Appellant argues, Müller relies on fiducial markers "detected in projections by identifying centroids of fiducial markers positions through component analysis." Reply Br. 2; *see also* Appeal Br. 6.

Appellant's characterization of Müller accords with Müller's teaching of detecting fiducial markers through a "3-D connected component analysis . . . applied to identify the centroids of the marker positions in 3-D." Müller, *2. In particular, Müller uses pre-calibrated projection matrices to forward project the three-dimensional reference markers "onto each projection image yielding the 2-D reference points $r'_{i,j}$," where *i* is the marker and *j* is the projection image. *Id.* To correct for motion, Müller "estimates a 3-D rigid transformation for each projection image *j*, by fitting the forward projection of the 3-D reference marker position to the actual 2-D detected candidate points." *Id.* That is, Müller optimizes unknown parameters of transformation matrix M_j through objective function (2). *Id*. Three-dimensional rigid transformation M_j is used to compute a new calibration matrix that is used to perform a motion-compensated reconstruction, as shown in equation (3). *Id.* Thus, Müller's motion correction method increases the similarity between a calculated projection group and a measured projection group by minimizing differences between forward projected pre-calibrated reference markers and two-dimensional candidate points. *Id*.

Although Appellant fairly characterizes the teachings and suggestions of Müller, Appellant's arguments nonetheless fail to distinguish the claimed invention's increase of "a degree of similarity between the certain measured projection group and a calculated projection group" from the three-dimensional rigid transformation estimation algorithm of Müller. In particular, although the Specification discloses the use of a normalized gradient angle difference as the measure of similarity (*see* Spec. p. 12, ll. 23–26, 29, Fig. 4), the Specification broadly discloses that "other similarity measures can be used like a gradient correlation measure or a pattern intensity measure . . . a sum of squared differences, et cetera" (*id.* p. 12, ll. 26–29). Given this open-ended disclosure, the broadest reasonable interpretation of the claimed "degree of similarity" encompasses the difference between forward projected, three-dimensional reference markers and actual two-dimensional detected candidate points. Müller, *2.

Appellant further argues that Müller's "detected fiducial marker position is not one or several measured projections." Reply Br. 2. The detected fiducial marker positions, however, are *extracted* through fast radial symmetry transform processing of the two-dimensional projection images. Müller, *1–2. Thus, they serve as reference points extracted from and representative of the two-dimensional projection images. This enables minimization of the difference (which thereby increases the similarity) between the source two-dimensional projection images (i.e., measured projections) and a calculated projection group represented by the forward projected, pre-calibrated reference markers.

Accordingly, we sustain the Examiner's 35 U.S.C. § 103 rejection of claim 1 as unpatentable over the combined teachings of Müller and Barfuss, and claims 5, 14, 15, and 20, which Appellant does not argue separately. *See, e.g.*, Appeal Br. 7.

Appellant's remaining contentions, as they pertain to Kyme, Barfuss, Van der Bom, Pelc, Quist, and Allmendinger, are not responsive to the Examiner's findings. *See id.* at 7–9. In particular, Appellant fails to identify any deficiencies in Kyme. *Id.* Accordingly, we affirm the Examiner's additional 35 U.S.C. § 103 rejections.

CONCLUSION

Claims Rejected	**35 U.S.C. §**	**References**	**Affirmed**	**Reversed**
1, 5, 14, 15, 20	103	Müller, Barfuss	1, 5, 14, 15, 20	
1, 4, 6, 10–16, 19	103	Kyme, Barfuss	1, 4, 6, 10–16, 19	
2, 17	103	Kyme, Barfuss, Van der Bom	2, 17	
3, 18	103	Kyme, Barfuss, Pelc	3, 18	
7, 9	103	Kyme, Barfuss, Quist	7, 9	
8	103	Kyme, Barfuss, Allmendinger	8	
Overall Outcome			**1–20**	

TIME PERIOD FOR RESPONSE

No time period for taking subsequent action in connection with this appeal may be extended under 37 C.F.R. § 1.136(a). *See* 37 C.F.R. § 1.136(a)(1)(iv).

AFFIRMED