

Internal distribution code:

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

**Datasheet for the decision
of 25 June 2010**

Case Number: T 0266/07 - 3.4.01
Application Number: 98962092.7
Publication Number: 1047951
IPC: G01R 33/54, G01R 33/565,
G01R 33/561
Language of the proceedings: EN

Title of invention:

Rapid acquisition magnetic resonance imaging using radial
projections

Applicant:

WISCONSIN ALUMNI RESEARCH FOUNDATION

Headword:

-

Relevant legal provisions:

EPC Art. 123(2), 53(c), 52(1)

Relevant legal provisions (EPC 1973):

EPC Art. 84, 56

Keyword:

-

Decisions cited:

G 0001/07, T 0345/90, T 0701/91, T 0439/92, T 0970/00

Catchword:

-



Case Number: T 0266/07 - 3.4.01

D E C I S I O N
of the Technical Board of Appeal 3.4.01
of 25 June 2010

Appellant:

WISCONSIN ALUMNI RESEARCH FOUNDATION
614 North Walnut Street
Madison, WI 53705 (US)

Representative:

Samson & Partner
Widenmayerstrasse 5
D-80538 München (DE)

Decision under appeal:

Decision of the Examining Division of the
European Patent Office posted 18 September 2006
refusing European patent application
No. 98962092.7 pursuant to Article 97(1) EPC
1973.

Composition of the Board:

Chairman: B. Schachenmann
Members: F. Neumann
P. Fontenay

Summary of Facts and Submissions

- I. The appeal lies from the decision of the examining division to refuse the European patent application number 98 962 092.7.
- II. With the statement of grounds of appeal, the appellant requested that the decision be set aside and a patent be granted on the basis of one of the sets of claims filed therewith as a main request and first to third auxiliary requests.
- Oral proceedings were requested as an auxiliary measure.
- III. The appellant was summoned to oral proceedings and a communication setting out the preliminary opinion of the Board was issued. In response to this communication, the appellant filed additional sets of claims forming auxiliary requests 4 to 7.
- IV. During the oral proceedings, objections were raised under Article 123(2) EPC and Article 84 EPC 1973 against claim 1 of the main request and of the first to third auxiliary requests. In view of these objections and as a result of the ensuing discussion of the fourth auxiliary request, the appellant filed claims 1 to 3 forming the basis of a sole request.
- V. In the present decision, the following citations will be taken into account:

D1: EP-A-0 073 671;

D4: EP-A-0 132 975;

D7: EP-A-0 629 876.

VI. Independent claim 1 of the sole request reads as follows:

"Method for producing a magnetic resonance angiogram of selected vasculature in a subject, wherein a contrast agent has previously been introduced into the selected vasculature so that the intensity of the NMR signal of the vasculature dominates the intensity of NMR signals in other materials within an entire field of view, comprising the steps:

- a) operating the MRI system to perform a pulse sequence which includes:
 - i) producing an RF excitation pulse to excite spins in the entire field of view which includes the selected vasculature;*
 - ii) applying a phase encoding gradient along a first axis;*
 - iii) applying a radial gradient directed at an angle θ in a plane perpendicular to the first axis; and*
 - iv) acquiring an NMR signal during the application of the radial gradient to sample an angular projection of the data in k-space having NR data points radially spaced along a projection;**
- b) repeating step a) with a set of different phase encoding gradient values for each of a plurality of different radial gradient angles θ until k-space is sampled,*
wherein the plurality of different radial gradient angles θ is less than NR $\pi/4$ in number so that a sparsely sampled three-dimensional k-space data set is acquired;

c) *Fourier reconstructing along the first axis a three-dimensional volume image of the entire field of view from the sparsely sampled k-space data set, whereby the spacial resolution of the resulting image is not affected by the sparse angular sampling and the artifacts associated with the sparse angular sampling are acceptable being no more than a few percent of the signal associated with the tissue surrounding the vasculature,*

d) *providing reduction of image artifacts generated by the sparse sampling by subtracting from the image reconstructed in step c), a mask image of the selected vasculature that was acquired before the contrast agent was introduced into the selected vasculature; and*

e) *displaying the reconstructed image produced in step d)."*

Claims 2 and 3 are dependent claims.

VII. The arguments of the appellant, insofar as they are pertinent to the present decision, are set out below in the reasons for the decision.

Reasons for the Decision

1. Reference is made to the transitional provisions for the amended and new provisions of the EPC, from which it may be derived which Articles of the EPC 1973 are still applicable to the present application and which Articles of the EPC 2000 shall apply.
2. The appeal is admissible.

3. *Article 123(2) EPC and Article 84 EPC 1973*

The Board is satisfied that the objections under Article 123(2) EPC and Article 84 EPC 1973 have been overcome by the amendments carried out during the appeal proceedings.

The basis for the amendments to claim 1 may be found on page 6, line 5 to page 8, line 11; page 17, line 5 to page 18, line 15; page 11, lines 18-19; page 10, lines 10-12 and 28-31 and claims 8 and 10 of the original application documents.

4. *Article 53(c) EPC*

4.1 In paragraph 1 of the reasons for the contested decision, the examining division found that the claimed method of producing a magnetic resonance angiogram (MRA) implicitly included the invasive step of introducing - by injection - a contrast agent into the vasculature of a patient to be examined, and refused the claims under Article 52(4) EPC 1973 on the grounds that the method had a surgical character. The Board does not agree with this finding.

4.2 It is noted that since the contested decision was issued, the Enlarged Board of Appeal has handed down decision G 1/07, in view of which the objection under Article 52(4) EPC 1973 raised in is no longer valid.

In particular, section 4.3.2 of G 1/07 holds that "*Methods which are merely directed to the operating of a device without themselves providing any functional interaction with the effects produced by the device on*

the body are teachings in which the performance of a physical activity or action that constitutes a method step for treatment of a human or animal body by surgery or therapy is not required in order for the teaching of the claimed invention to be complete. Hence, even if in such a case the use of the device itself requires the application of a surgical step to the body or is for therapeutic treatment the same does not apply to the claimed method for operating the device."

4.3 In the present case, the claimed method is directed to the operating of a magnetic resonance imaging (MRI) system. Whilst the presence of a contrast agent is indeed obligatory for the imaging method defined in claim 1, the method for operating the MRI device is not functionally related to the actual administration of the contrast agent. Claim 1 must be interpreted as only covering the production of an MRA of a vasculature into which a contrast agent has already been introduced. Thus, the actual step of introducing the contrast agent into the vasculature is not included within the scope of the method claim.

4.4 When this interpretation is invoked the method according to claim 1 represents a technical method for producing an MRA of a selected vasculature by means of a magnetic resonance imaging system, and not a surgical method. Claim 1 is therefore not concerned with a method of surgical treatment of the human or animal body within the meaning of Article 53(c) EPC and is, therefore, not excluded from patentability under this provision.

5. *The invention*

Claim 1 relates to a method for producing a magnetic resonance angiogram. Data is acquired using undersampled projection reconstruction in the x-y plane combined with phase encoding and Fourier reconstruction along the z-axis. In addition, mask subtraction is used to improve the quality of the resulting image.

When using projection reconstruction (PR), the spatial resolution is determined not by the number of radial projections, but rather by the number of radial sample points within each projection. Hence, simply by reducing the number of projections used in the imaging, the rate at which high resolution images can be achieved can be increased. Although such undersampling does not affect the spatial resolution, it does give rise to potentially disruptive artifacts. However, when the undersampled PR is combined with contrast enhancement in the regions to be imaged, i.e. the vasculature, the bright, contrast-filled vessels dominate and the artifacts become insignificant in relation thereto. Thus, in the limited field of contrast-enhanced magnetic resonance angiography, high frame rate acquisition factors can be achieved without appreciably degrading the diagnostic value of the resulting images. Combined with phase encoding along the z-axis, the speed of 3D imaging can be significantly increased with respect to conventional Cartesian 3D imaging.

6. *Inventive step - Article 52(1) EPC, Article 56 EPC 1973*

6.1 In general terms, D1 discloses a two-dimensional MRI method in which a projection reconstruction technique is employed. In D1, two types of image are created. In order to monitor the imaging process, a series of intermediate "rough" images are produced. These rough images are acquired from undersampled k-space data sets, each of which is derived from different, interleaved radial projection views, the number of radial projection views for each rough image being less than the number required for fully-sampled k-space. These rough images can be displayed individually and employed in their own right to monitor any time-lapse variation of the slice being imaged. The "final" image, which corresponds to fully-sampled k-space, is produced by combining all of the interleaved data sets. However, it is the method of producing the "rough" images which the Board considers to represent the closest prior art.

6.2 The method of claim 1 is distinguished from the method of producing the rough images in D1 at least in the following respects:

(a) No reference is made in D1 to the application of a phase encoding gradient along a first axis or indeed to the repetition of the pulse sequence with a set of different phase encoding gradient values and the Fourier reconstruction of a 3D volume image of the entire field of view from the sparsely sampled k-space data set.

(b) No reference is made in D1 to the mask subtraction step.

(c) No specific reference is made in D1 to the production of an angiogram.

Whether D1 may be considered to disclose the use of a contrast agent in combination with MRI was the subject of some debate. However, as will become apparent in the following, this point is in fact purely academic and so can be left open.

6.3 Each of the above-identified differences gives rise to a different technical effect. In particular, the technical effect of difference (a) is that three dimensional imaging is achieved: positional information in the third dimension is obtained by the phase encoding. The technical effect of difference (b) is that the quality of the final image is improved by removing the artifacts. The technical effect of difference (c) is that a specific organ, namely the vasculature, is imaged.

These technical effects represent an aggregation of isolated effects which have no interdependence. When assessing inventive step, each of the above-identified differences may therefore be considered separately; for the subject-matter of the claim to be considered inventive, it suffices to show that just one of these differences is not obvious (T 345/90, reasons, point 5 and T 701/91, reasons, points 6.4 and 6.5). Since the Board considers that it is not obvious to combine the method of producing the rough images of D1 with phase-encoding and Fourier reconstruction in the third dimension, the question of whether differences (b) and (c) involve an inventive step - and indeed the question

of whether D1 discloses the use of a contrast agent in combination with MRI - may be left open.

6.4 Although D1 is the one document which appears to contain the largest number of relevant technical features in common with claim 1, the Board considers that D1 does not actually represent a suitable starting point for an attack on inventive step. In particular, when applying the problem-solution approach, the objective problem which is formulated must be one which the skilled person would realistically consider addressing when setting out from the starting point.

A conscious choice of starting point, made in the knowledge of the respective benefits and drawbacks of the various prior art disclosures, not only determines the subject-matter serving as a starting point but also defines the framework for further development (T 439/92, reasons, point 6.2.4). Taking the disclosure of D1 as the starting point, the skilled person cannot ignore the fact that the very reason for resorting to the rough images in D1 is to enable fast image acquisition: it is in order to achieve rapid imaging that the quality of the intermediate images is willingly sacrificed. The speed of imaging is consequently an inseparable part of the disclosure of D1 and defines that framework within which any further development of the imaging method of D1 must be carried out. In view of this context, the Board is of the opinion that the construction of any argument which involves the development of the imaging method of D1 in a manner which would compromise the speed of imaging would be counter-intuitive and can only be seen as the result of an ex-post facto analysis. Although it may be

argued that the combination of two-dimensional PR imaging of D1 with phase encoding and Fourier reconstruction along the z-direction may present the most obvious way in which to obtain 3D images from the 2D PR images of D1, the speed of imaging is of such fundamental importance in D1 that the skilled person starting from D1 would not forfeit this aspect.

- 6.5 The examining division argued that there was an obvious desire to extend the technique of D1 to the acquisition of 3D data. The Board does not agree.

In view of the fast-imaging framework of D1, the Board agrees with the appellant that the inevitable delay involved in the processing time when employing phase encoding along the z-axis is so contrary to the declared aim of D1 that the skilled person would simply not consider adapting the method of producing the rough images in D1 to include phase encoding and Fourier reconstruction in the third dimension. Starting from D1, an "obvious desire" to extend to 3D imaging cannot therefore be recognised.

- 6.6 The examining division further argued that the purpose of the technique of D1 was to obtain an early indication of any problems which may have arisen during the imaging and which may corrupt the final image such that they can be corrected as soon as possible. If the final image is to be a 3D image, then the rough, early-warning images must also contain 3D information.

The Board agrees that, in principle, it may be desirable to provide intermediate 3D images during a 3D scan. However, this implies starting from a 3D imaging

method and developing it to provide intermediate images. This approach will be discussed in relation to D4 below.

- 6.7 The Board is therefore of the opinion that starting from D1, the skilled person would not consider it obvious to adopt the combination of 2D PR rough imaging with phase encoding and Fourier reconstruction in the third dimension. Starting from D1, the subject-matter of claim 1 is therefore not obvious.
- 6.8 It is noted that D7 discloses a similar method to that of D1. Claim 1 is also distinguished from D7 in that a phase encoding gradient is applied along the third dimension and that a Fourier reconstructed 3D volume image is acquired from a sparse radial sampling of k-space. For the same reasons as given with respect to D1, the subject-matter of claim 1 cannot be considered obvious when starting from D7.
- 6.9 In the view of the Board, D4 represents a more realistic starting point for the development of the present invention. D4 relates to a method of NMR imaging using spin-echo techniques and discusses various pulse sequences for sampling k-space in different ways. Using a $90^\circ/180^\circ$ RF pulse combination to excite a slice at a position along the z-axis, spin echo signals are acquired in the presence of a readout gradient to acquire k-space data along a radial path. Projections are acquired at different view angles to sample a single 2D slice. D4 mentions that the 2D projection reconstruction may be combined with Fourier imaging techniques: the two dimensions in the x-y plane can be reconstructed from data taken as multiple angle

projections where the planes are defined by phase encoding along the z-axis and are reconstructed by Fourier transformation (D4, page 56, lines 21-27).

The examining division was of the opinion that D4 may be considered to disclose sparse sampling since, at least for the first few samples, k-space is undersampled.

As set out in T 970/00 (reasons, point 4.1.2), any attempt to interpret the disclosure of the closest prior art so as to distort or misrepresent, based on hindsight knowledge of the invention, the proper technical teaching of the disclosure in such a way that it artificially meets specific features recited in the claim under consideration must fail. In the present case, when regarding the entire teaching of D4, it is clear that undersampling is not used in the method of image production. The interpretation of the examining division is not considered to reflect the teaching that a skilled reader would extract from D4 without knowledge of the invention. The Board is of the view that D4 cannot be reasonably considered to disclose a method of MR imaging using an undersampling regime.

6.10 In very general terms, the method of claim 1 is therefore distinguished from the 3D imaging method of D4 in that:

- (a) k-space is undersampled to the extent that the number of radial projections is less than $NR \pi/4$, whereby NR is the number of data points radially spaced along a projection;

(b) contrast enhancement and mask subtraction are employed; and

(c) an angiogram of a selected vasculature is produced.

6.11 The technical effect of difference (a) is to increase the imaging rate. As a disadvantageous consequence of the undersampling, the images will contain radial streak artifacts. The technical effect of difference (b) is to make these artifacts visually less apparent in the final image.

6.12 When starting from D1, the method steps distinguishing claim 1 from the disclosure of D1 were seen to be functionally independent of each other. In contrast thereto, starting from D4, the relationship between the above-identified differences (a) and (b) is one of functional reciprocity: these two elements in fact complement each other and the invention may be seen to lie in the deliberate combination thereof. The contrast agent is employed in order to tackle the disruptive artifacts which inevitably arise as a result of the undersampling. When deciding on inventive step starting from D4, the question to be answered is therefore not whether the individual elements of the combination were known or obvious from the prior art, but whether the state of the art would lead the skilled person to this particular combination.

6.13 D1 teaches that images of acceptable quality (acceptable, that is, for at least certain applications) may be achieved even if the number of radial projections is reduced to such an extent that k-space is undersampled. However, D1 makes it clear that such

images resulting from undersampling are merely "rough" images. The skilled person would realise that this is because at the outside edge of k-space, the circumferential sampling points are spaced too far apart to satisfy the Nyquist criteria and this inevitably gives rise to streaking artifacts due to the inadequate sampling and aliasing of high spatial frequencies.

Nevertheless, provided the artifacts can be tolerated, in order to speed up the image acquisition procedure of D4, the Board is of the opinion that the skilled person would consider adopting the undersampling regime of D1 by decreasing the number of radial projections to thereby rapidly achieve high-resolution images throughout the entire field of view. However, in doing so he would have to consciously accept the inevitable degradation of the image quality. D1 contains no teaching as to how to solve the problem of this image degradation. In particular, even in view of the inevitable presence of artifacts, D1 does not teach to use a contrast medium to visually minimise these with respect to the imaged vessel.

- 6.14 Although contested by the appellant, the Board believes that D1 may be considered to at least suggest that MR imaging of a vessel is performed after introduction of a contrast agent so as to enable time-lapse tracking of organs (D1, page 4, line 8 to page 5, line 3). The Board is aware of the fact that a combination of contrast enhanced MRI with the sparse PR sampling of D1 will lead - by default - to high resolution 2D images of the same quality as the 3D images resulting from the method of claim 1 before mask subtraction is performed.

Thus, although not addressed in D1, when 2D rough images are obtained in the presence of a contrast medium, these images will inevitably be of the same quality as the 3D images of the present invention. D1, however, contains not the slightest suggestion that the reason for using a contrast agent may be to counter any streaking artifacts resulting from the PR undersampling. Instead, the contrast agent is used to accentuate the vessels of interest in comparison to the surrounding material. Thus, although D1 may be considered to suggest contrast-enhanced MRI, it does not lead the skilled person to the recognition that as long as contrast enhancement is employed, the artifacts resulting from undersampling will no longer significantly disrupt the image.

Hence, starting from D4, in order to solve the problem of faster imaging, the aspect which the skilled person would extract from the teaching of D1 would be that of sparse PR sampling. Nothing in D1 would lead the skilled person to solve the related problem of making the artifacts more tolerable by employing a contrast agent. Indeed none of the cited prior art documents teaches this deliberate combination. It is therefore not obvious to supplement the sparse radial sampling with contrast enhancement when attempting to speed up the imaging process.

6.15 As a result, the Board concludes that neither starting from D1 nor starting from D4 would the skilled person arrive at the subject-matter of claim 1 in an obvious manner.

Order

For these reasons it is decided that:

1. The decision under appeal is set aside.

2. The case is remitted to the examining division with the order to grant a patent based on
 - claims 1 to 3 filed in the oral proceedings;
 - description pages 4, 5, 10 and 14 as published and pages 1 to 3, 3a, 6 to 9, 11 to 13, 15 to 18, 18a, 19 to 21 filed in the oral proceedings;
 - drawing sheets 1/7 to 7/7 as published in WO 99/30179, A3, corrected version.

The Registrar:

The Chairman:

S. Sánchez Chiquero

B. Schachenmann