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**Datasheet for the decision
of 11 May 2012**

Case Number: T 0818/08 - 3.4.01

Application Number: 02718813.5

Publication Number: 1354215

IPC: G01R 33/28, G01R 33/561

Language of the proceedings: EN

Title of invention:
Magnetic resonance angiography using undersampled 3D
projection imaging

Applicant:
WISCONSIN ALUMNI RESEARCH FOUNDATION

Opponent:
-

Headword:
-

Relevant legal provisions:
EPC Art. 123(2), 53(c)

Relevant legal provisions (EPC 1973):
EPC Art. 84, 56

Keyword:
-

Decisions cited:
G 0001/07

Catchword:
-



Case Number: T 0818/08 - 3.4.01

D E C I S I O N
of the Technical Board of Appeal 3.4.01
of 11 May 2012

Appellant:
(Applicant)

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Decision under appeal:

Decision of the Examining Division of the
European Patent Office posted 27 November 2007
refusing European patent application
No. 02718813.5 pursuant to Article 97(1) EPC
1973.

Composition of the Board:

Chairman: G. Assi
Members: F. Neumann
J. Geschwind

Summary of Facts and Submissions

- I. The appeal, filed on 28 January 2008, lies from the decision of the examining division, dispatched on 27 November 2007, to refuse European patent application number 02 718 813.5. The appeal fee was paid on 28 January 2008. The statement setting out the grounds of appeal was filed on 07 April 2008.
- II. The following documents, cited during the examining proceedings, will be referred to in the present decision:
- D2: Scheffler K. et al.; "Reduced Circular Field-of-View Imaging"; Magnetic Resonance in Medicine, Academic Press, Duluth, MN, US; vol. 40, 1998, pages 474-480;
- D4: US-A-5 502 385,
- D5: EP-A-0 798 566.
- III. The examining division refused the application for failure to comply with Articles 84, 123(2) and 52(1) EPC 1973. Claim 1 then on file was held to lack novelty but the examining division also indicated that, even if it were amended to make the intended meaning clear, it would still lack an inventive step.
- IV. With the statement of grounds of appeal, the appellant filed an amended set of claims 1-14 and amended description pages 5, 5a, 7 and 7a. Whilst amendments were filed to overcome some of the clarity objections of the decision, the appellant submitted that some of the other objections were unfounded and provided supporting arguments for this view. Arguments were also

submitted in support of inventive step of the independent claim. In particular, it was held that the image acquisition schemes of D2 and D5 were so far removed from the invention that the skilled person would not have considered adapting the teaching of either of these documents to arrive at the imaging method of claim 1. Moreover, a combination of these two documents would not lead to the subject-matter of claim 1.

- V. In a communication of the Board dated 29 February 2012, a number of objections under Article 123(2) EPC were raised. The main objection concerned the fact that claim 1 represented an intermediate generalisation of a specific embodiment that had been described in the original application. The Board indicated that the arguments concerning inventive step which had been submitted in the statement setting out the grounds of appeal appeared to be persuasive but that the claim must be clarified to distinguish the subject-matter defined therein from the prior art.
- VI. In response to this communication, by letter of 04 April 2012, the appellant filed three sets of claims forming the basis of a main request and first and second auxiliary requests. During the oral proceedings on 11 May 2012, these requests were replaced by a set of claims 1 to 10 forming the basis of a single request.
- VII. The appellant has requested that the decision under appeal be set aside and that a patent be granted on the basis of claims 1-10 filed during the oral proceedings on 11 May 2012, the description pages 5, 5a, 7 and 7a filed with the statement setting out the grounds of

appeal of 07 April 2008, pages 1-4, 6, and 8-23 as originally filed and Figures 1-9 as originally filed.

VIII. Claim 1 of the sole request reads:

"A method for operating a magnetic resonance imaging (MRI) system in order to produce a magnetic resonance image of a patient at a time during a dynamic magnetic resonance angiography (MRA) study, the steps comprising:

a) operating the MRI system to acquire a first undersampled k-space image data set at a first time during the dynamic MRA study using a three-dimensional projection reconstruction pulse sequence that is repeated to sample k-space throughout a spherical k-space volume comprising a central volume and a peripheral volume, and wherein the three-dimensional projection reconstruction pulse sequence is repeated a sufficient number of times to sample the central volume of k-space in accordance with the Nyquist condition but the number of repetitions of the three-dimensional projection reconstruction pulse sequence is less than one-half the number of repetitions necessary to fully sample the entire k-space volume in accordance with the Nyquist condition, wherein the angular spacing of the samples is chosen such that a uniform distribution of k-space sample points occurs at the peripheral boundary of the sampled k-space sphere;

b) operating the MRI system to acquire additional undersampled k-space image data sets at additional times during the dynamic MRA study using the three-dimensional projection reconstruction pulse sequence, wherein each first and additional undersampled k-space image data set samples different k-space locations

throughout the spherical k-space volume, and wherein the three-dimensional projection reconstruction pulse sequence is repeated a sufficient number of times to sample the central volume of k-space in accordance with the Nyquist condition but the number of repetitions of the three-dimensional projection reconstruction pulse sequence is less than one-half the number of repetitions necessary to fully sample the entire k-space volume in accordance with the Nyquist condition, wherein the angular spacing of the samples is chosen such that a uniform distribution of k-space sample points occurs at the peripheral boundary of the sampled k-space sphere;

c) forming a combined k-space image data set using the k-space data of the central and peripheral volume from one of said acquired undersampled k-space image data sets and only the k-space data of the peripheral volume from at least one of the adjacent acquired undersampled k-space image data sets; and

d) reconstructing an image using the combined k-space image data set."

Claims 2 to 10 are dependent claims.

Reasons for the Decision

1. The appeal is admissible.
2. *Article 123(2) EPC*
 - 2.1 Independent claim 1

2.1.1 Any amendment which presents the skilled person with new information which was not directly and unambiguously derivable, either explicitly or implicitly, from the original application is prohibited under Article 123(2) EPC. Thus it has to be examined whether the new claim 1 comprises technical information which a skilled person would not have objectively and unambiguously derived from the application as filed.

2.1.2 Claim 1 is directed to a method of operating a magnetic resonance imaging (MRI) system in order to produce a magnetic resonance (MR) image of a patient at a time during a dynamic magnetic resonance angiography (MRA) study. The operation of the system involves sampling k-space using a three-dimensional projection reconstruction (PR) pulse sequence. The PR pulse sequence is repeated along different angular views such that a first set of samples is acquired. Additional sets of samples are acquired at subsequent times in the dynamic study in the same manner, the angular views of each of the acquired sets representing different angular views in k-space. Data from at least two of the sets of samples are combined in the manner defined in step (c) of claim 1 and this combined data set is used to reconstruct an image.

2.1.3 The subject-matter of claim 1 is derived from an intermediate generalisation of the specific embodiment of page 19, line 19 to page 21, line 8. Some of the features of this specific embodiment have been isolated and combined with the features of original claim 1 whilst other details of the specific embodiment have been omitted from the new claim. Specifically, the acquisition and combination of multiple data sets was

disclosed in the specific embodiment of pages 19 to 21 only in the context of **contrast enhanced** magnetic resonance angiography (CEMRA). Similarly, the acquisition and combination of multiple data sets was the subject of original claims 12 to 14 which were also directed to a CEMRA method. The omission of the reference to contrast enhancement in claim 1 presents the skilled person with the information that the steps of acquiring and combining multiple undersampled data sets can be used in any MRA application and not just in contrast enhanced MRA.

2.1.4 From the outset, the original application makes clear that the invention concerns magnetic resonance angiography (MRA) in general, the use of contrast agents to enhance the MR signals being merely a preferred manner of operation (see the title on page 1 of the originally filed description and page 1, lines 9-11).

Indeed, the skilled person is aware that MRA does not necessarily require the use of contrast agents. The appellant made reference to column 3, line 28 to column 4, line 14 of D5 which briefly explains that two groups of techniques are used for vascular imaging, namely time-of-flight (TOF) and phase contrast (PC), neither of which require contrast enhancement. The use of contrast agents to enhance the MRA images may be seen as a third technique.

Page 7, line 7 to page 8, line 2 of the original application sets out three aspects of the invention in the "Summary of the invention". The first aspect concerns the recognition that when using a projection

reconstruction sampling scheme, k-space can be significantly undersampled yet clinically useful images can still be obtained. The second aspect is a development of the first aspect and concerns the recognition that the time resolution of a series of temporally separated images in a dynamic study can be increased by using this undersampled PR technique. The third aspect is a development of the second aspect and concerns the removal of artifacts from the images acquired in the dynamic study by combining the data sets of successive images of the dynamic study.

As was argued by the appellant, although the "Summary of the invention" makes reference in all three aspects to dynamic **CEMRA** studies, the field of the invention is presented on page 1 as pertaining only to MRA: studies of the human vasculature using contrast agents were only mentioned in an "and particularly" clause. Indeed, the presence of contrast agent is not obligatory in any of these three aspects for the sampling and processing steps set out in claim 1.

Moreover, the method of original claim 1, which was directed to the first aspect, was not restricted to a CEMRA method, but instead concerned only the details of the specific sampling scheme per se, no reference being made to the environment in which the MR imaging is performed. It is therefore apparent that the second and third aspects of the invention - which are further developments of the first aspect - need not be restricted to CEMRA.

Furthermore, as the appellant pointed out, page 21, lines 18-19 of the original application states that

"The present invention may also be employed to produce a phase contrast MRA image." Here, the reference to "the present invention" must be understood in the light of page 7, line 7 to page 8, line 2 in which the three aspects of the invention are summarised. In particular, the third aspect of the invention, namely the acquisition of multiple data sets to obtain dynamic imaging and the combination of data sets to improve the spatial resolution and remove the inevitable artifacts, may be used in phase contrast (as opposed to contrast enhanced) MRA imaging. Thus, the Board considers that the skilled person would understand from the passage on page 21 that the sampling sequence and data processing described in the originally filed application in the particular context of CEMRA need not be restricted to contrast enhanced applications, but can indeed be applied to any MRA technique.

2.1.5 Hence, the intermediate generalisation is considered to be justified in the light of the teaching of the whole application.

2.2 Dependent claims 2-7

Dependent claims 2 to 7 correspond to dependent claims 2 to 7 of the original application. However, in the original application, these claims were dependent on claim 1 which made no reference to multiple data sets or to the combination of various data sets.

Being originally dependent on claim 1 means that these claims represent further details of the basic undersampled PR imaging method. It is this method that forms the basis of the more complex imaging method

currently presented in claim 1 in which the basic undersampled PR imaging method of original claim 1 is repeated to form additional data sets which are then combined in a specific manner to arrive at a series of temporally separated images of improved spatial resolution. Hence any further details of the basic method of original claim 1 are also be applicable to the more complex method defined in the current version of claim 1.

2.3 Dependent claims 8-10

The subject matter of claim 8 is derivable from claims 15 and 16 as originally filed. Basis for claim 9 may be found in Figure 7, page 19, lines 23-26 and claim 20 of the original application. The subject matter of claim 10 is derivable from claim 18, page 21, lines 18-21 and page 22, lines 13-25.

2.4 Consequently, the Board is satisfied that the subject-matter of the amended claims does not extend beyond the teaching of the application as originally filed.

3. *Article 84 EPC 1973*

In the contested decision a number of clarity issues were raised which the Board considers to have been overcome by the amendments made during the appeal proceedings.

In particular the independent claim now specifies that the distribution of sampling points at the peripheral boundary of the sampled k-space volume is uniform. Whether or not the uniform distribution is achieved by

means of synthesizing k-space samples may remain open and does not, in the Board's view, render claim 1 unclear. It is now clear that the "peripheral k-space data" are those data sampled from the k-space outside the central, fully sampled volume. The sampling trajectories have not been restricted in claim 1 to straight line trajectories in view of the fact that other sampling trajectories which give rise to the uniform spacing of sampling points referred to above may be adopted. The Board considers that it is now clear that the k-space data samples of the first data set are taken from different k-space locations to those of each of the additional data sets. Whether or not the Nyquist condition is satisfied for the combined peripheral data is not relevant: what is important is that the undersampled periphery is supplemented by additional data.

4. *Article 53(c) EPC*

- 4.1 Claim 1 is directed to "A method for operating a magnetic resonance imaging (MRI) system in order to produce a magnetic resonance image of a patient at a time during a dynamic magnetic resonance angiography (MRA) study". The method steps set out in claim 1 concern only the acquisition and processing of k-space data and the reconstruction of an image on the basis of the processed data.

The Board acknowledges that the production of an image "during a dynamic MRA study" encompasses the production of a contrast enhanced image during a dynamic CEMRA study which in turn requires that a contrast agent be introduced to the vasculature for the study. However,

the Board considers that any potential introduction of contrast agent to the patient - in particular, by injection - does not form part of the claimed method.

4.2 Section 4.3.2 of decision G 1/07 (OJ EPO 2011, 134) 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 operation of an MRI system. Whilst the presence of a contrast agent would indeed be obligatory should a contrast enhanced MRA image be produced, the sampling steps and data processing steps set out in claim 1 are not functionally related to the actual administration of the contrast agent. The method of claim 1 is directed exclusively to the operation of the MRI device to the extent that k-space is sampled in a specific manner, the temporally separated k-space data sets resulting from the claimed sampling scheme are combined in a specific manner and an image is reconstructed from the combined k-space image data set. Any potential step of injecting a contrast agent into the vasculature is not encompassed by the wording of the method claim and

the question of whether the injection of contrast agent is of a surgical nature therefore does not arise.

4.4 The method according to claim 1 therefore represents a technical method for operating an MRI system, and not - even potentially - 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. *Article 56 EPC 1973*

5.1 D2 is considered to represent the closest prior art. This document discloses a rapid dynamic imaging technique using angular k-space sampling. By reducing the angular sampling density, the temporal resolution is improved but the radius of the corresponding field of view (FOV) is reduced. If the dynamic changes may be assumed to be restricted to a small region of interest, angular undersampling allows artifact-free imaging of these changes in a reduced imaging time.

In the section entitled "Reduced Circular FOV Technique" on page 478, D2 explains the steps involved in the dynamic imaging technique. This involves obtaining a full FOV reference image before the dynamic imaging is performed, this reference image being derived from fully-sampled k-space. Undersampled reduced FOV dynamic images are then obtained. The full FOV reference image is used to supplement the dynamic image with the static parts of the reference image which are located outside the reduced FOV region.

A preferred sampling scheme of D2 involves acquiring the dynamic images by using an interleaved acquisition scheme consisting of eight or sixteen successive eight- or sixteen-fold angular undersampled k-space scans, each rotated by one angular increment. It is noted that by combining all eight or all sixteen of the undersampled data sets, a combined data set representing fully-sampled k-space may be obtained and used to provide the full FOV reference image.

D4 discloses a very similar angular interleaved sampling scheme (column 4, lines 17-35). Here, even when all of the undersampled data sets are combined, the MR image is still of low spatial resolution but is nevertheless clinically useful (column 4, lines 44-65). The spatial resolution can be enhanced by increasing the number of angular projections used in each data set, i.e. by increasing the sampling density (column 5, lines 40-46).

In both of these sampling schemes, when interleaved undersampled data sets are combined to produce a data set of greater sampling density, all of the data of each set is combined with all of the data of every other set in the combination.

- 5.2 The subject-matter of claim 1 is distinguished from this scheme in that the combined k-space image data set of claim 1 is formed by all k-space data from one of the undersampled data sets and *only* the peripheral k-space data from one or more of the temporally adjacent data sets. The present invention exploits the fact that projection reconstruction sampling methods sample the centre of k-space more densely than the periphery.

Indeed, the central region is identified as the region in which the sampling density is high enough to satisfy the Nyquist condition. The missing structure definition of the image resulting from the sparse sampling of peripheral k-space is "filled in" by using peripheral data from other undersampled data sets.

5.3 D5 relates to a Cartesian acquisition scheme in a dynamic MRA study. The k-space is divided into a central region and three peripheral regions. The basic teaching of D5 is that the central region of k-space is sampled at a higher rate than the peripheral regions during the dynamic study. This is achieved by alternately sampling the central region and sequential ones of the peripheral regions. A combination of the sampled data from the central region and the three temporally closest peripheral samplings forms a combined data set sufficient to reconstruct an image with good spatial resolution: each central data set is supplemented by the peripheral k-space data from the three temporally nearest adjacent data sets.

5.4 The Board can recognise no motivation for the skilled person to combine the individual sampling schemes of D2 and D5 which both relate to different imaging scenarios. Indeed, none of the cited documents suggest that the technique used in the Cartesian acquisition scheme of D5 could be applied to projection reconstruction imaging. Moreover, as argued by the appellant, even if the skilled person were to consider combining the two teachings, it is not apparent how this combination would lead the skilled person to the sampling and processing steps set out in claim 1.

Applying the Cartesian "filling in" scheme to the interleaved PR acquisition scheme of D2 would result in the angular sampling projections being split into a central region and three peripheral regions. Adopting the sampling scheme of D5 would then require that the central region of k-space be alternately sampled with sequential ones of each of the peripheral regions. This would mean that the data sets containing the peripheral data do not contain any central data. This sampling scheme does not correspond to the claimed sampling scheme in which **each** data set is made up of fully sampled central k-space and undersampled peripheral k-space. The combination of the teachings of D2 and D5 would therefore not lead the skilled person to the sampling scheme set out in claim 1.

5.5 Thus, the subject matter of claim 1 does not derive in an obvious manner from the cited prior art.

Order

For these reasons it is decided that:

1. The decision under appeal is set aside.

2. The case is remitted to the department of the first instance with the order to grant a patent on the basis of the set of claims 1-10 filed during the oral proceedings on 11 May 2012 and a description to be adapted thereto.

The Registrar:

The Chairman:

R. Schumacher

G. Assi