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D E C I S I O N
of 27 September 1995

Case Number: T 0406/93 - 3.4.2

Application Number: 86309781.2

Publication Number: 0249666

IPC: G01C 21/00

Language of the proceedings: EN

Title of invention:
Satellite camera image navigation

Applicant:
SPACE SYSTEMS / LORAL INC.

Opponent:
-

Headword:
-

Relevant legal provisions:
EPC Art. 56

Keyword:
"Inventive step - no"

Decisions cited:
-

Catchword:
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Chambres de recours

Case Number: T 0406/93 - 3.4.2

D E C I S I O N
of the Technical Board of Appeal 3.4.2 of 27 September 1995

Appellant: SPACE SYSTEMS / LORAL INC.
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Decision under appeal: **Decision of the Examining Division of the European Patent Office dated 7 December 1992 refusing European patent application No. 86 309 781.2 pursuant to Article 97(1) EPC.**

Composition of the Board:

Chairman: E. Turrini
Members: R. Zottmann
L. C. Mancini

Summary of Facts and Submissions

I. European patent application No. 86 309 781.2 with publication No. 0 249 666 was refused by decision of the Examining Division.

The reason given for the refusal was that the independent claims were unclear since the majority of the features were defined in functional terms providing no information as to the structural adaptation of the means defined by those features and since, moreover, they did not involve an inventive step with respect to document

D4: International Symposium on Remote Sensing of the Environment, Environmental Research Institute of Michigan, 21 October 1985, D. W. Graul: posterboard display, sheets 1-17.

II. The Appellant lodged an appeal against said decision.

III. In a communication accompanying the summons to oral proceedings the Board expressed its preliminary opinion that the subject-matter of the independent claims filed together with the Statement of the Grounds of Appeal did not involve an inventive step with respect to documents

D3: A. Schwalb: "Envirosat-2000 Report: GOES-Next Overview"; U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Washington, D.C., September 1985, pages i-iii and 1 to 38,

and D4. During the oral proceedings the Appellant presented a main set of claims with a slightly restricted claim 1 and an auxiliary set of claims with a more restricted claim 1. The Board expressed its preliminary opinion that these claims were neither inventive. With respect to claim 1 of the auxiliary request, the Board referred to the corresponding findings of the Examining Division that the additional features represent standard orbit and attitude calculation practice, this being demonstrated for example by the standard textbook passages

D5: A. E. Roy: "Orbital Motion", Adam Hilger Ltd., Bristol 1982, pages 25-28 and 369-370, and

D6: H. Goldstein: "Classical Mechanics", Addison-Wesley, Mass. USA, 1980, pages 478-479.

IV. The independent claim according to the main request reads as follows:

1. "1. A system for locating any pixel within a satellite image in terms of latitude and longitude with respect to a celestial body, said system comprising:

a satellite adapted for orbiting the celstial body;

an imaging camera (1) on board the satellite for taking images of scenes on the celestial body and for dividing each image taken by the camera (1) into a plurality of pixels;

the imaging camera (1) being arranged additionally to provide star data;

modelling means (40, 50, 60) for generating estimates of the orbital parameters of the satellite as a function of on the basis of measurements of stars and of the celestial body taken by the camera (1) and for generating an estimate of the attitude of the camera on the basis of measurements of stars taken by the camera (1) only;

coupled to said modelling means, means (66) for transforming pixel locations as announced by the camera (1) into latitude and longitude coordinates with respect to the celestial body."

Claims 2 to 11 are dependent on claim 1.

2. The independent claim according the auxiliary request reads as follows:

"1. A system for locating any pixel within a satellite image in terms of latitude and longitude with respect to a celestial body, said system comprising:

a satellite adapted for orbiting the celstial body;

an imaging camera (1) on board the satellite for taking images of scenes on the celestial body and for dividing each image taken by the camera (1) into a plurality of pixels;

the imaging camera (1) being arranged additionally to provide star data;

modelling means (40, 50, 60) for generating an estimates of the orbital parameters of the satellite as a function of time on the basis of measurements of stars and of the celestial body taken by the camera (1) and for generating an estimate of the attitude of the camera on the basis of measurements of stars taken by the camera (1) only;

coupled to said modelling means, means (66) for transforming pixel locations as announced by the camera (1) into latitude and longitude coordinates with respect to the celestial body;

wherein the modeling means (40, 50) is adapted for simultaneously generating estimates of the satellite orbit and the camera attitude; and is adapted for generating the orbit estimate as an expression of the satellite's latitude and longitude at the subsatellite point, and of the altitude of the satellite, as a function of time, said orbit estimate comprising coefficients which are the six Keplerian elements at epoch; said modeling means being further adapted for generating estimates of the Keplerian elements using a walking least squares fit based upon star and celestial body landmarks."

Claims 2 to 10 are dependent on claim 1.

V. The arguments of the Appellant with respect to claim 1 of both requests can be summarized as follows:

An important difference between D3 and claim 1 of both requests consists in that D3 does not disclose the modelling means of claim 1 providing estimates of orbit and attitude using in the interval between the estimates the time-dependent mathematical function as interpolation function. The skilled person would, to increase the accuracy of orbit and attitude determination, carry out measurements more frequently and/or immediately before and after taking an image. Nowhere in D3 or D4 it is stated that the **camera's** attidude is determined. D3 page 35 at the bottom to page 36 at the top contains merely a statement recognizing that orbit and attitude change with time.

As to claim 1 of the auxiliary request, both D3 and D4 are silent about the exact method of calculation of orbit and attitude.

Reasons for the Decision

1. The appeal is admissible.

2. *Requirements of Article 123(2) EPC*

The Board is satisfied that claims 1 of both requests do not contain subject-matter extending beyond the content of the application as originally filed.

3. *Requirements of Article 84 - clarity*

Some features of present claims 1 of both requests are defined by relatively broad expressions relating to the method of operation of the system ("... being arranged ... to provide ...", "means ... for generating ...", "means ... for transforming ..."). In view of the far developed satellite technique and orbit calculation practice and computers at the application date, the Board is of the opinion that said expressions provide the person skilled in this technical field with sufficient information to choose and adapt the means (e.g. the satellite, the camera, the modelling and the transforming means) such that they - and the system defined by said means - are suitable to carry out the steps of said method of operation.

4. *Novelty*

None of the available documents explicitly discloses a system for locating any pixel within a satellite image comprising modelling means for generating estimates of the orbital parameters of the satellite as a function of time. Therefore, the subject-matters of claims 1 of both requests are considered to be new within the meaning of Article 54 EPC.

5. *Inventive step of claim 1 of the main request*

5.1 The closest prior art with respect to the subject-matter of claim 1 is D4.

This document discloses a system for locating any pixel within a satellite image in terms of latitude and longitude with respect to the earth, and thus a celestial body, (see e.g. sheet 13 first half: "IMAGE NAVIGATION AND REGISTRATION -Image navigation is the process of determining the location of each pixel within an image in terms of earth latitude and longitude" in combination with sheet 3 showing the "GOES I,J,K SYSTEM" with telemetering and processor means for carrying out said pixel location step) comprising a satellite adapted for orbiting said body (the GOES satellites used in D4, see e.g. on top of sheet 4), an imaging camera on board the satellite for taking images of scenes on said body and for dividing each image taken by the camera into a plurality of pixels (see sheet 13 first half and sheet 5 ("System Approach") first half), the imaging camera being arranged additionally to provide star data (see sheet 13: "Star and landmark measurements are taken directly by the Imager ...") and means for determining the orbit on the basis of measurements of stars and of the celestial body taken by the camera and for determining the attitude on the basis of measurements of stars taken by the camera only (see said sheet 13 lines 7 to 11 in combination with sheet 3). Since the location of each pixel within a satellite image is to be determined in terms of earth latitude and longitude, it is absolutely necessary that the system of D4 contains means for transforming pixel coordinates relative to the image camera into said earth coordinates.

Details of the kind of the orbit and attitude determination processes and of said pixel transformation process and the corresponding means to carry out such processes are not described in D4. In particular, D4 does not disclose the determination of the orbit by generating estimates of the orbital parameters of the satellite as a function of time and the determination of the attitude by generating an estimate of the attitude of the camera.

The advantage to be obtained by these relatively simple measures is an improved accuracy of the pixel location within a satellite image in terms of latitude and longitude with respect to earth.

5.2 The problem to be solved by the invention was therefore to give details of the orbit and attitude determination processes by means which are relatively simple but do not suffer inaccuracies.

5.3 When the skilled person is seeking for details for performing the determination of the orbit and the attitude as dislosed in D4 sheet 13, he would take into consideration D3, since D3 as well as D4 (and the application-in-suit) refer to the so-called GOES-Next system, that is the geostationary meteorological satellite system I, J, ... following GOES G and H (see in D4 sheet 2 ("BACKGROUND") and in D3 page ii at the bottom, pages 1, 3 and 17).

D3 states (see page 35 last but one para to page 36 line 6) that the image navigation process of the GOES-Next system should provide transformation of the pixel position into earth longitude and latitude. This would require knowledge of the orbital position and the attitude of the optical axes of the instrument - and thus of the attitude of the imaging camera - as a function of time.

Such functions are mathematical estimates using mathematical models of the orbit of the satellite expressed in orbital parameters (see, e.g., D5 Section 2.6 and D6) and the attitude of the instrument, that is the imaging camera, and require corresponding means adapted to provide such estimates and, respectively, to establish such models. Similarly, said transformation of the pixel locations within an image requires corresponding transformation means connected to said means for establishing the models and suitable to transfer the pixel location coordinate(s) within the image with respect to the camera. Continuous updating of said functions according to D4, that is by using fresh range, star and landmark data for the orbit function and by fresh star data for the instrument attitude function, is a matter of course. To take into account changes of the orbital parameters with time and thus to improve the accuracy of the determination of the earth coordinates of the pixels of the images, the skilled person would take into consideration establishing an interpolation function for the parameters using the values of the parameters determined when updating them. This leads to estimates of the orbital parameters of the satellite as a function of time.

Such an interpolation function is one option, an increase of the frequency of the measurements, above all before and after taking an image, is a further option to improve the accuracy of the determination of the earth coordinates of the pixels and simultaneous use of both options is a third option. If, however, the orbit parameters are only slowly moving functions of time - slowly with respect to the time intervals between taking images, which apparently applies to geostationary satellites of the type used according to the example of the application and in D3 and D4 - , an option with a interpolation function would be preferred by the skilled person.

5.4 It follows from the above that the question whether the subject-matter of claim 1 of the main request involves an inventive step has to be answered in the negative.

6. *Inventive step of claim 1 of the auxiliary request*

Claim 1 of the auxiliary request is formed by introducing the features of claims 6 and 10 of the main request into claim 1 of the main request, but the introduced features add nothing inventive to it.

In particular: Simultaneous generating of the satellite orbit estimate and the camera attitude estimate is a trivial and preferred option to accelerate the process of determination of pixel coordinates (earth longitude and latitude) if only the processor's capacity is high enough. The details of the generation of the orbit estimate contained in the last paragraph of claim 1 deal with standard orbit and attitude modelling techniques using the determination of the six orbital or Keplerian elements at epoch (see D5 and D6) and a usual best fit algorithm to take into account the latest measurements. The thus determined orbit has then to be transformed into more useful coordinates (see e.g. D5) which would, in view of the required transformation of the pixel location, include longitude and latitude with respect to the celestial body. It is an obvious choice of a suitable orbit model of a geostationary satellite being preferably used in the system of the application, D3 and D4 to describe the orbit as an expression of the satellite's latitude and longitude at the subsatellite point, and of the altitude of the satellite, all of these of course as functions of time.

Therefore, also the subject-matter of claim 1 of the auxiliary request does not involve an inventive step.

7. The Board, therefore, comes to the conclusion that the subject-matter of claim 1 of the main request as well as of the auxiliary request lack an inventive step in the sense of Article 56 EPC. Consequently, both requests are not allowable having regard to Article 52(1) EPC.

Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar: The Chairman:

P. Martorana E. Turrini