Title: STEREO DISPLAY OF TUBE-LIKE STRUCTURES AND IMPROVED TECHNIQUES THEREFOR ("STEREO DISPLAY")

Abstract: Improved systems and methods for stereoscopically displaying and virtually viewing tube-like anatomical structures are presented. Stereoscopic display of such structures can provide a user with better depth perception of the structure being viewed and thus make a virtual examination more real. In exemplary embodiments according to the present invention, ray shooting, coupled with appropriate error correction techniques, can be utilized for dynamic adjustment of an eye convergence point for stereo display. In exemplary embodiments of the present invention, the correctness of a convergence point can be verified to avoid a distracting and uncomfortable visualization. Additionally, in exemplary embodiments of the present invention, convergence points in consecutive time frames can be compared. If rapid changes are detected, the system may compensate by interpolating transitional convergence points. In exemplary embodiments according to the present invention ray shooting can also be utilized to display occluded areas behind folds and protrusions in the inner colon wall. In exemplary embodiments according to the present invention, interactive display control functionalities can be mapped to a gaming-type joystick or other threedimensional controller, freeing thereby a user from the limits of a twodimensional computer interface device such as a standard mouse or trackball.

A

B

cave and polyp, hard to distinguish
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

G06T15/00 H04N13/00 G09B23/28

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

G06T H04N G09B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic database consulted during the international search (name of database and, where practical, search terms used)

EPO-Internal, INSPEC, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
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<tbody>
<tr>
<td>X</td>
<td>US 5 611 025 A (LORENSEN ET AL) 11 March 1997 (1997-03-11) columns 1,5; figures 4,5 -----</td>
<td>1,4-9, 28, 29</td>
</tr>
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</table>

Further documents are listed in the continuation of box C.

Patent family members are listed in annex.

* Special categories of cited documents:

A* document defining the general state of the art which is not considered to be of particular relevance

E* earlier document but published on or after the international filing date

L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

O* document referring to an oral disclosure, use, exhibition or other means

P* document published prior to the international filing date but later than the priority date claimed

O* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

* document member of the same patent family

Date of the actual completion of the international search

3 November 2005

Date of mailing of the international search report

0 3: 03. 06

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax. (+31-70) 340-2015

Authorized officer

Ellerbrook, T

Form PCT/ISA/210 (second sheet) (January 2004)
<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
</thead>
</table>
| X        | RIO A D ET AL: "Efficient stereoscopic rendering in virtual endoscopy applications"  
JOURNAL OF WSCG UNIV. WEST BOHEMIA CZECH REPUBLIC,  
vol. 11, no. 1,  
7 February 2003 (2003-02-07), pages 95-101, XP002352207  
ISSN: 1213-6972  
abstract  
----- | 1,4,7-9 |
| X        | WO 03/083781 A (KONINKLIJKE PHILIPS ELECTRONICS N.V.; LOBREGT, STEVEN)  
9 October 2003 (2003-10-09)  
page 3, line 20 - page 4, line 8  
----- | 1,4-9 |
### Box II  Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.: because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.: because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

3. ☐ Claims Nos.: because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

### Box III  Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

- see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☑ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

   1-9, 28, 29

**Remark on Protest**

- ☐ The additional search fees were accompanied by the applicant's protest.
- ☐ No protest accompanied the payment of additional search fees.
This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-9, 28, 29

Providing overview in virtual stereoscopic navigation of the colon (or arteries) by showing next to the stereoscopically displayed section of the colon an overview image of the colon together with the path so far traversed and the current position of the virtual camera

2. claims: 10-15, 22-24, 30, 31

Flight pass generation in virtual colonoscopic navigation. The average of points on the colon surface which is visible from the current viewpoint is taken as the next viewpoint (i.e. camera position) in a series of points to be determined. Visibility is determined only for some points on the wall by sending rays from the current position (ray shooting) and computation of the intersection point with the wall.

3. claims: 16-19

Computation of a continuous series of convergence points (where to look points) of the virtual stereo camera in virtual colonoscopy by ray shooting and temporal interpolation of found points

4. claims: 20-21

Convenient user interface in virtual guided or manual colonoscopy for the control of the translation of the virtual camera, its yaw, pitch (i.e. its viewing direction) and its roll (i.e. its rotation around its optical axis); zooming of its virtual optics and finally the start and end point of its traveling path through e.g. the colon of a special 6D controller with special buttons.

5. claims: 25-27

Detection of obstacles (e.g. folds, polyps) and rendering them transparent to enable sight onto blind spots (occluded sections) in virtual colonoscopy. Obstacles are found by counting how often the ray hits the colon surface or by comparing the distance between the current viewpoint and hit points.
<table>
<thead>
<tr>
<th>Patent document cited in search report</th>
<th>Publication date</th>
<th>Patent family member(s)</th>
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<tbody>
<tr>
<td>US 5611025 A</td>
<td>11-03-1997</td>
<td>CN 1135047 A</td>
<td>06-11-1996</td>
</tr>
<tr>
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<td></td>
<td>DE 19543410 A1</td>
<td>27-06-1996</td>
</tr>
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<td></td>
<td>IL 116011 A</td>
<td>09-05-1999</td>
</tr>
<tr>
<td></td>
<td></td>
<td>JP 8252217 A</td>
<td>01-10-1996</td>
</tr>
<tr>
<td></td>
<td></td>
<td>JP 2005521960 T</td>
<td>21-07-2005</td>
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<td>US 2005151730 A1</td>
<td>14-07-2005</td>
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